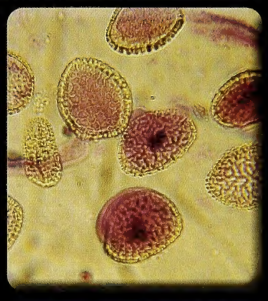
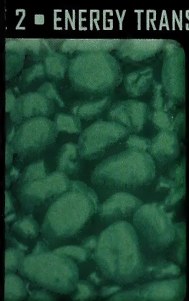
University of Alberta Library
0 1620 3502978 2

SCIENCE 14

MODULE 2 ■ ENERGY TRANSFER TECHNOLOGIES





Learning Technologies Branch

Alberta LEARNING

Digitized by the Internet Archive
in 2016 with funding from
University of Alberta Libraries

https://archive.org/details/science1402albe_0

SCIENCE 14

MODULE 2 ■ ENERGY TRANSFER TECHNOLOGIES

ENERGY TRANSFER TECHNOLOGIES ■ MODULE 2 ■ ENERGY TRANSFER TECHNOLOGIES ■

ILE 2 ■ ENERGY TRANSFER TECHNOLOGIES ■ MODULE 2 ■ ENERGY TRANSFER TECHNOLOGIES ■ MODULE 2 ■

Science 14
Module 2: Energy Transfer Technologies
Student Module Booklet
Learning Technologies Branch
ISBN 0-7741-2511-X

The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	

You may find the following Internet sites useful:

- Alberta Learning, **http://www.learning.gov.ab.ca**
- Learning Technologies Branch, **http://www.learning.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.learning.gov.ab.ca**

The use of the Internet is optional. Exploring the electronic information superhighway can be educational and entertaining. However, be aware that these computer networks are not censored. Students may unintentionally or purposely find articles on the Internet that may be offensive or inappropriate. As well, the sources of information are not always cited and the content may not be accurate. Therefore, students may wish to confirm facts with a second source.

ALL RIGHTS RESERVED

Copyright © 2003, the Crown in Right of Alberta, as represented by the Minister of Learning, Alberta Learning, 10155 – 102 Street, Edmonton, Alberta T5J 4L5. All rights reserved. Additional copies may be obtained from the Learning Resources Centre.

No part of this courseware may be reproduced in any form, including photocopying (unless otherwise indicated), without the written permission of Alberta Learning.

Every effort has been made both to provide proper acknowledgement of the original source and to comply with copyright law. If cases are identified where this effort has been unsuccessful, please notify Alberta Learning so that appropriate corrective action can be taken.

IT IS STRICTLY PROHIBITED TO COPY ANY PART OF THESE MATERIALS UNDER THE TERMS OF A LICENCE FROM A COLLECTIVE OR A LICENSING BODY.

UNIVERSITY LIBRARY
UNIVERSITY OF ALBERTA

Welcome to

SCIENCE 14

Science 14 contains four modules.
You should work through the modules in order (from 1 to 4) because concepts and skills introduced in one module will be reinforced, extended, and applied in later modules.

MODULE 1
■ INVESTIGATING PROPERTIES OF MATTER ■

MODULE 2
■ ENERGY TRANSFER TECHNOLOGIES ■

MODULE 3
■ FROM LIFE TO LIFESTYLE ■

MODULE 4
■ MATTER AND ENERGY IN THE BIOSPHERE ■

Contents

6 **Course Features**

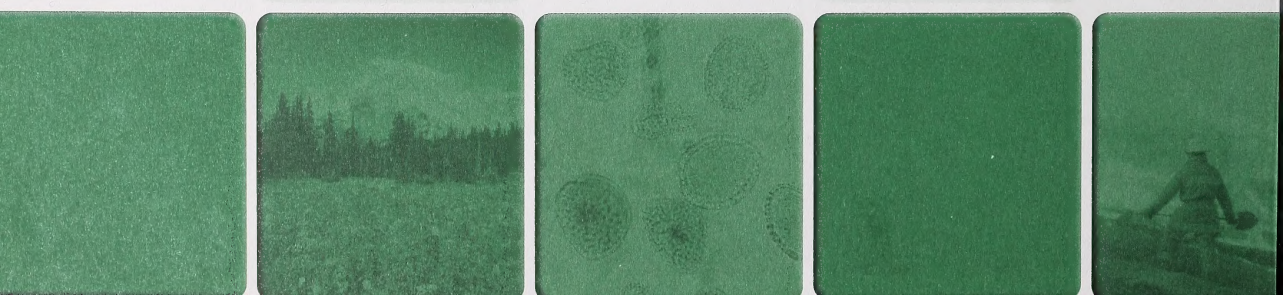
8 **Module Overview**

10 **Section 1:** Heat and Heat Transfer

- 11 **Lesson 1:** The Nature of Heat
- 19 **Lesson 2:** Heat and Temperature
- 22 **Lesson 3:** Transfer of Heat
- 28 **Lesson 4:** Heat Transfer in Nature
- 35 **Lesson 5:** Heat Transfer and Technologies
- 39 **Section 1 Review**

41 **Section 2:** Controlling Heat Transfer

- 42 **Lesson 1:** Absorbing and Losing Heat
- 50 **Lesson 2:** Keeping Heat at Home
- 59 **Lesson 3:** Keeping Yourself Warm
- 63 **Section 2 Review**



65 **Section 3:** Simple Machines and Energy Transfer
66 **Lesson 1:** All Kinds of Energy
77 **Lesson 2:** Just Prying into Things
84 **Lesson 3:** Wheels, Pulleys, and Blocks
91 **Lesson 4:** Spinning Our Wheels: Energy and Efficiency
97 **Section 3 Review**

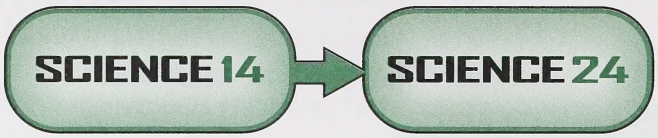
99 **Module Summary**

101 **Appendix**
102 **Glossary**
103 **Suggested Answers**
158 **Image Credits**

Course Features

The Science 14–24 Program

Science 14 is the first course in the Science 14–24 sequence of courses. If you successfully complete each of these five-credit courses, you will meet the minimum requirement in science for an Alberta high school diploma.



The Science 14–24 sequence is designed for students whose needs, interests, and abilities focus on basic science understanding. This course sequence emphasizes scientific and related technological knowledge and skills that will enable you to understand and interpret the world around you.

Consult your teacher or counsellor for the latest information on Science 14. Also, if you have access to the Internet, you can find out more about Science 14 and high school requirements at the Alberta Learning website.

http://www.learning.gov.ab.ca

This Science 14 course consists of four modules. Each module consists of one Student Module Booklet and two Assignment Booklets. The booklet you are presently reading is called a Student Module Booklet. It will show you, step by step, how to advance through each module.

Resources You Will Need

Textbook

To complete the course, you will need the textbook *Science.Connect 1*.

Multimedia

Attached to the inside cover of the textbook and to Module 1 of this course are multimedia CDs. These CDs contain multimedia segments designed to help you better understand particular concepts presented in this course. Ask your teacher, friend, or family member if you need help using these CDs.

Looseleaf Binder or Notebook

Because response lines are not provided in the Student Module Booklets, you will need a looseleaf binder or notebook to respond to questions and complete charts. It's important to keep your lined paper handy as you work through the material and to keep your responses together in a binder for review purposes later.

Materials and Apparatus

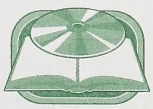
The modules include numerous science activities and investigations that require materials and apparatus. A lab kit is not needed to complete this Science 14 course. Many of the activities and investigations are set up so you can complete them using common household materials. Some investigations, however, do require lab material and apparatus. These investigations are set up with a Part A and a Part B. If you have access to a supervised laboratory facility, you may complete Part A of these investigations. If you do not have access, Part B will provide you with an alternate pathway.

Visual Cues

You will find many visual cues throughout this course. Colour is used to highlight the important terms that are defined in the Glossary of the Appendix. You will also encounter some icons in the margins. Read the following explanations to find out what each icon prompts you to do.

Refer to the textbook.

Refer to the multimedia CD given in Module 1.

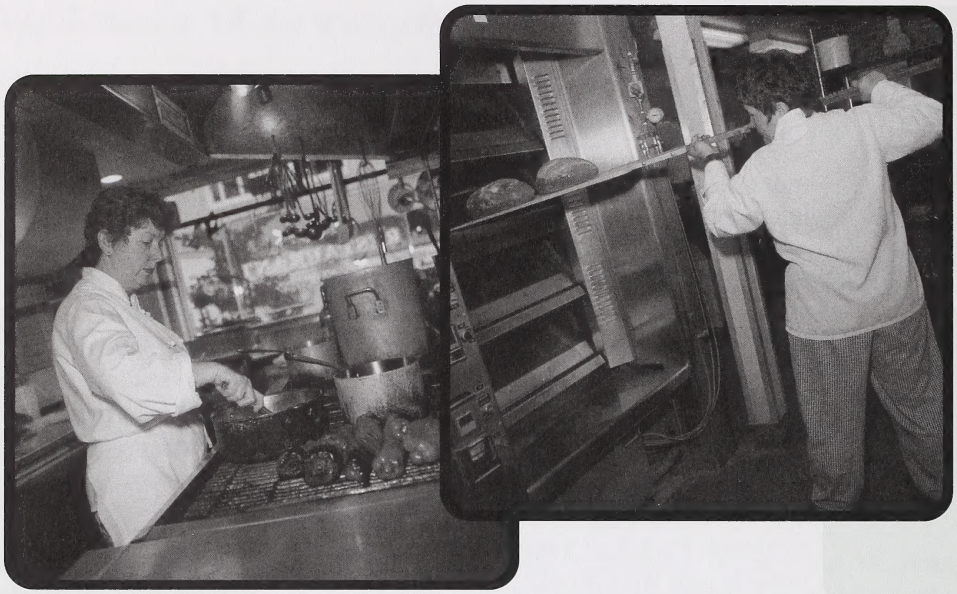

Refer to the multimedia CD given in the textbook.

Use the Internet.
Note: Any website given is subject to change.

Pay special attention to the safety precautions mentioned.

Answer questions in the Assignment Booklet.

Module Overview



Do you enjoy a well-cooked meal? You won't be surprised that there is a lot of work involved in making a delicious dinner. There is, however, a lot more going on than the effort the chef puts in. Behind the scenes, for example, the stove is generating heat for the food in the pots and pans; the oven is generating enough heat so the bread will bake perfectly. Somehow, this heat from the stove and oven is being transferred to the food only—the chef is not getting cooked along with the food! Within the food there are chemical reactions occurring that make everything taste just right.

Notice that the title for this module includes the word *transfer*. When cooking food, heat energy is transferred in several different ways. In this module you will learn about how heat is transferred from one object to another, as well as how to reduce heat transfer. You will also find that heat is only one form of energy. You will then see how other forms of energy can be transferred as well.

Assessment and Feedback

This module, Energy Transfer Technologies, has three sections. Within each section, your work is grouped into lessons. Within the lessons, there are readings, activities, investigations, and questions for you to do. By completing these lessons, you will discover scientific concepts and skills, practise or apply what you have learned, and develop a positive attitude toward science.

Suggested answers to the questions are provided in the Appendix of this Student Module Booklet. They will provide you with immediate feedback to the questions you complete in the lessons.

At several points in this Student Module Booklet, you will be directed to the accompanying Assignment Booklets. Your grading in this module is based on the assignments you submit for assessment. In this module you are expected to complete three section assignments.

The mark distribution is as follows:

Assignment Booklet 2A	
Section 1 Assignment	50 marks
Assignment Booklet 2B	
Section 2 Assignment	35 marks
Section 3 Assignment	31 marks
Total	**116 marks**

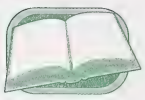
You will be asked to submit each Assignment Booklet to your teacher once it is completed. Your teacher will then mark your Assignment Booklet and give you feedback as to how you are doing. Once you get your Assignment Booklet back, be sure you review your teacher's comments and correct any errors you made.

Section 1

HEAT AND HEAT TRANSFER

What do you think a volcano would look like from the International Space Station? The picture here might give you a hint. It was taken from the Space Shuttle. It's amazing that it can be seen so clearly. Most things that people build cannot be seen easily from space. Volcanoes are large and powerful reminders that Earth has a hot core.

A volcano is a great example of heat transfer. It is a product of the heat at Earth's core. The molten rock, ash, and gases produced can make for a spectacular picture. A volcano can also completely devastate the surrounding area. You might find the area around Mount Vesuvius in Italy interesting. When Mount Vesuvius erupted, entire towns were covered and lay undisturbed for centuries. All this was caused by a tiny part of the heat in Earth's core moving to the surface.



Turn to pages 80 and 81 of the textbook. Read the introduction to "Chapter 5: Heat and Heat Transfer." After reading the introduction, read "Science Log." Think about the questions that are asked. You will learn more about these questions in this section. You should also read over the points in "What You Will Learn," "Why It Is Important," and "Skills You Will Use" on page 81. These parts provide a brief overview of what will be covered in this section.

Lesson 1

The Nature of Heat

People and animals like flowers. The reasons may be quite different, but the appeal is there. If you were asked to decide if flowers were more important in biology or physics, which would you choose? It's pretty clear how flowers fit into the biological sciences. In this lesson you will see how flowers play an important role in the physical sciences.

Turn to page 82 of the textbook and read the first paragraph of "Robert Brown and Random Movement."

The next investigation will show that water is made up of moving particles, even water that appears to be stationary.

Investigation

5-A: Mysterious Motion

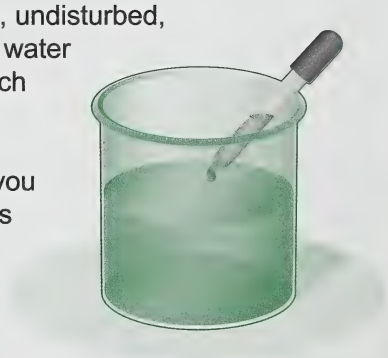
Turn to pages 84 and 85 of the textbook and read the entire investigation. This investigation will be modified for this course. Read the following changes.

Materials and Appartus Modifications

- You can substitute a clear glass, jar, or mug for the beaker. You need to be able to observe what is happening from the side of the container.
- Food colouring usually comes in containers that dispense a drop at a time. You can use that feature rather than using a medicine dropper. (**Warning:** Food colouring is very concentrated. It can permanently stain clothing and other porous materials.)
- You can use hot tap water for the hot water part of the investigation.

Additional Instructions

- After putting water into the container, let it sit, undisturbed, for 2–3 minutes. This will make sure that the water is still. Don't leave it too long or it will approach room temperature.



- While you let the water sit, write down what you predict will happen when the food colouring is dropped into the water.
- Drop the food colouring into the water from very close to the surface. Try to use the same distance for both the hot and cold water.
- Try not to disturb the containers of water during the investigation.

You need to carefully observe what happens after the food colouring enters the water for 1–2 minutes. Write down your observations.

1. As you work through the investigation, complete a lab report using the following template. Fill in the template with information about this investigation.

Title: *(What is a good name for this investigation?)*

Problem: *(What is this investigation trying to determine?)*

Prediction: *(What do you think the answer to the problem is?)*

Materials and Apparatus: *(What materials and apparatus were used?)*

Procedure: *(What steps did you follow to carry out this investigation?)*

Observations: *(What did you see during the investigation?)*

Conclusions: *(What is the answer to the problem? Was your prediction correct?)*

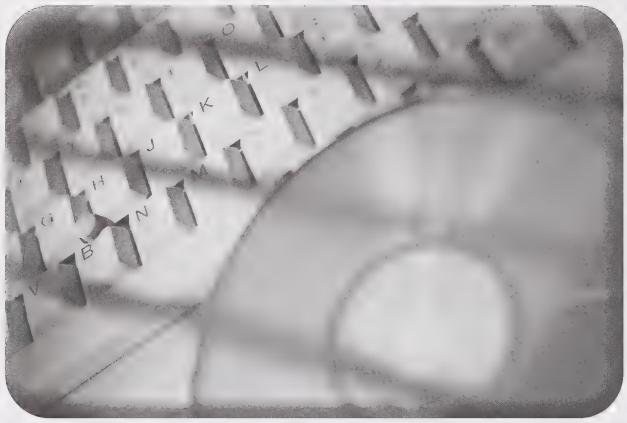
2. Answer questions 1, 2, and 3 of "Analyze" on page 85 of the textbook.

3. Answer questions 4 and 5 of "Conclude and Apply" on page 85 of the textbook.

Check your answers on pages 103 to 105 of the Appendix.

Turn to page 83 of the textbook. Continue your reading on "Robert Brown and Random Movement." It will summarize Robert Brown's observations and give his explanation for them.

Now, read "Disc Connect" on page 83. Then insert the *Science.Connect 1 Student Multimedia* CD into your computer. Launch the applet *Brownian* from the Brownian folder. Follow the instructions. This applet will add to your understanding of **Brownian motion**.



Answer the following questions based on the information in the applet.

4. What were Robert Brown's observations when he observed pollen grains in a drop of water under a microscope?

5. What name was given to the zigzag motion of the particles?

6. What explanation did Robert Brown eventually propose for the motion of pollen grains?

7. How is Brownian motion affected by temperature?

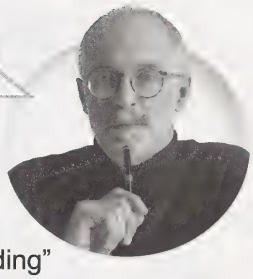
8. How does a pollen grain move when suspended in water?

9. Write the accepted hypothesis for Brownian motion.

10. Give the reason stated in Part 6 of the *Brownian motion* applet as to why this hypothesis is acceptable.

Check your answers on page 105 of the Appendix.

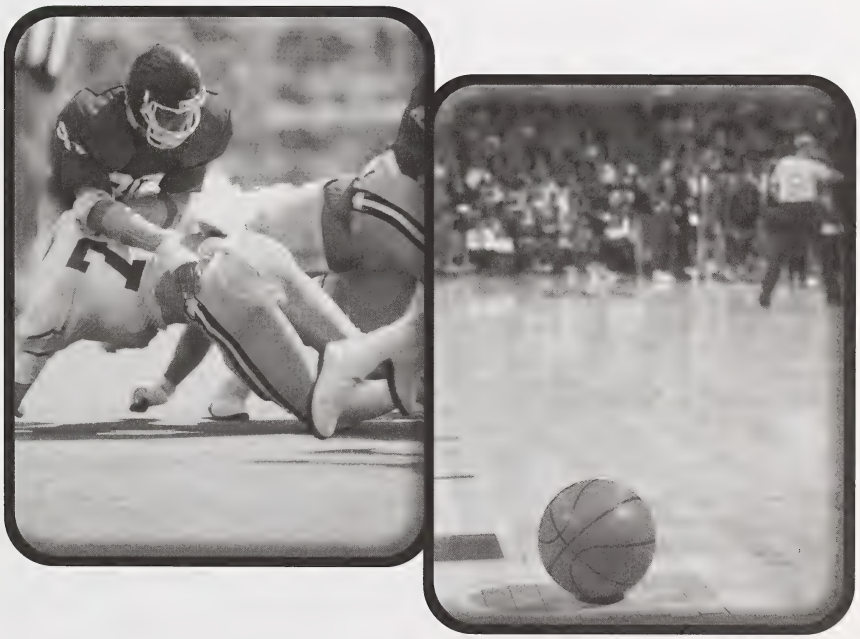
You just learned that water molecules hitting pollen grains is an example of Brownian motion and that pollen grains move faster as the temperature of the water increases.



11. Answer questions 1, 2, and 3 of "Check Your Understanding" on page 85 of the textbook.

Check your answers on page 105 of the Appendix.

You will now look at other examples of how heat and motion are related. Rubbing things together causes them to get hotter. Professional football players regularly get rug burn when sliding on artificial turf. Have you ever gotten rope burn from a tug of war or from pulling something with a rope? How about sliding on the gym floor and getting a floor burn? Either of these incidents will convince you that **friction** causes heating.



Starting Point
Activity

Where Does Heat Come From?

Read through the entire activity on page 81 of the textbook. If you have the proper equipment, you can work through this activity with a responsible adult.

Do not use an electric drill for this activity. The bit can become hot enough to cause burns.

If you are unable to carry out this activity, try the following.

12. Answer questions 1, 2, and 3 of "What Do You Think?"

CHECK Check your answers on page 105 of the Appendix.

Before matches and lighters were invented, starting a fire wasn't easy. The textbook method is much more technological than just rubbing two sticks together. The wooden pieces have been carefully shaped. The friction is concentrated at the point of the rotating stick. A person's hands (or a bow as on page 81 of the textbook) are used to change straight-line motions to circular ones. The result is a more efficient fire starter.

Turn to page 82 of the textbook and read the introductory paragraphs of "The Nature of Heat." You will read about a man by the name of Count Rumford. Another example of motion and heat being related is also given. Rubbing things together generates heat, in some cases extremely large amounts of heat.

Rumford discovered more about friction and heat. He found that he could heat water to its boiling point and keep it boiling by boring a cannon barrel under water with a blunt bit. At his time in history, the accepted theory was that heat was a substance, called caloric. It was thought to be an oil-like fluid. A major proponent of this idea was Antoine Lavoisier. Rumford's work showed that when heating a cold object, the weight of the object did not increase. Do you think that considering heat to be a weightless, oily substance makes sense?

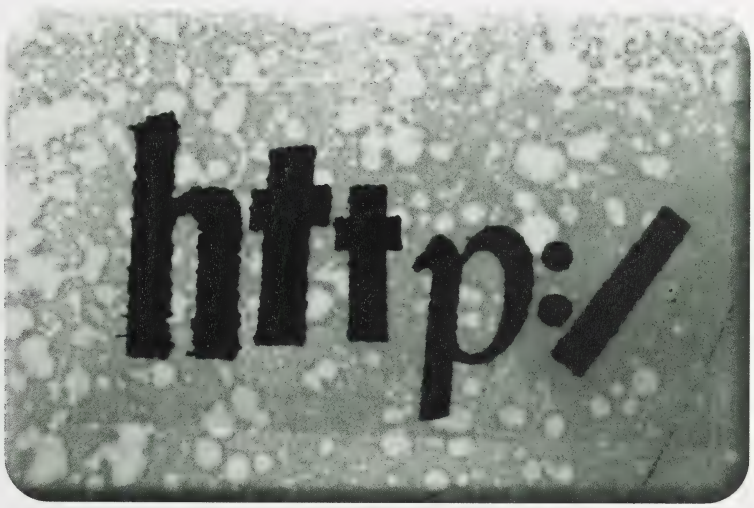
13. What did Count Rumford's worker discover about the drill bit that had just been used to bore a cylinder of steel to make a cannon?

14. What did Count Rumford notice about heat?

Check your answers on page 106 of the Appendix.

If you want to read Count Rumford's own discussion, you can find it at the following website:

http://dbhs.wvusd.k12.ca.us/Chem-History/Rumford-1798.html



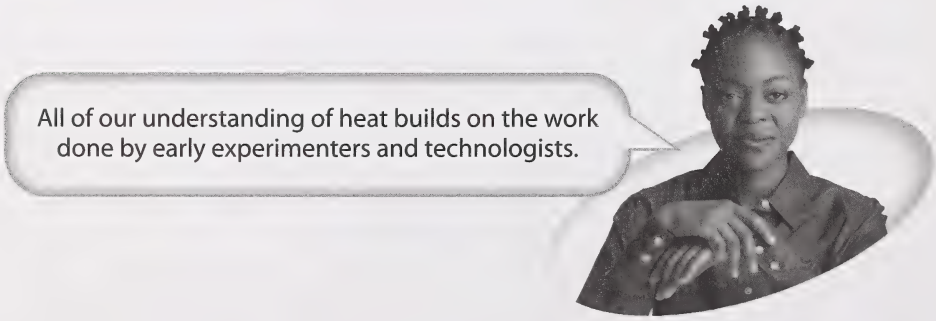
Rumford's information was useful to later scientists. They developed the theory that heat was related to motion. One of these scientists, James Joule, has been immortalized in the SI system. The **joule (J)** is the unit for energy. His experiments helped demonstrate the conservation of energy.

James Joule (1818–1889)

Joule showed that mechanical energy and heat could be interchanged. He devised a way to use a falling weight to heat water. (You'll have to pardon the non-metric measurements. Joule was working in nineteenth century England. They used the English system of measurement.) In early experiments, Joule found that it took an 890-pound weight falling 1 foot to heat 1 pound of water 1 degree Fahrenheit. Later experiments, with better equipment, reduced the weight to 772 pounds.

If you want to read Joule's own discussion, you can find it at the following website:

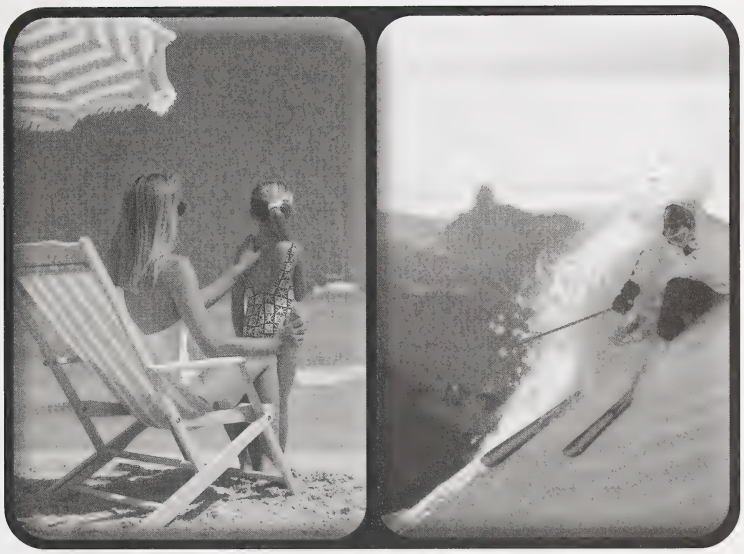
http://dbhs.wvusd.k12.ca.us/Chem-History/Joule-Heat-1845.html



Go to pages 1 and 2 of Assignment Booklet 2A and answer questions 1 to 6.

Lesson 2

Heat and Temperature



Alberta experiences a wide variety of temperatures. There is the gorgeous, hot weather that makes lakes and beaches tempting; and there are the cool, snowy days that make skiing and snowboarding great. A temperature of 30°C is great for going to the beach. At a temperature of –30°C, it is a little too cold to enjoy a run down the slopes. You are about to see how scientists view heat and temperature.

Get Prepared

In this lesson and in Lesson 3 of this section, you will need small ice cubes. You should prepare these now so they will be ready when you need them. Make 12 or more ice cubes, each with 15 mL (1 tablespoon) of water. (They all need to be the same size.) Make the ice cubes in a regular ice-cube tray or in an empty plastic tray from a finished box of chocolates (with fairly regular shapes). When you use some of the ice cubes, replenish your supply.

Activity

Amount of Thermal Energy

Try this little activity to convince yourself that there is more **thermal energy** or heat in a large glass of hot water than in a small glass.

> **Note:** The textbook and this Student Module Booklet discuss *thermal energy* and *heat* as if the two terms have the same meaning. However, scientists who study thermal energy and heat in detail have precise definitions of both terms.

Materials and Apparatus:

- 2 similarly sized glasses or cups
- 2 small ice cubes (Refer to "Get Prepared" on the previous page.)
- hot tap water

Be very careful when handling hot water.

Procedure:

step 1: Fill one glass full of hot tap water.

step 2: Pour one quarter of the water into the second glass.

step 3: Add one ice cube to each glass.

step 4: Observe which ice cube melts first.

1. a. Sketch a diagram of the activity immediately after the ice cubes were added.

   b. Sketch a diagram of the activity immediately after one of the ice cubes melts.

2. Describe what you observed in this activity.

3. Which glass contained more thermal energy?

Check your answers on page 106 of the Appendix.

Turn to page 86 of the textbook. Read the information in "Heat and Temperature." Pay careful attention to the two diagrams near the bottom of the page. The first part of the reading reviews the particle theory of matter and Robert Brown's role in its development. The second part introduces you to **kinetic energy**.

4. What did Robert Brown say thermal energy was related to?

5. What does kinetic energy measure?

6. How is temperature defined in terms of kinetic energy?

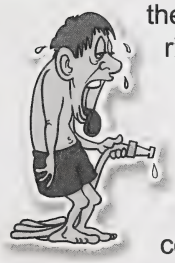
7. How is thermal energy (heat) defined in terms of kinetic energy?

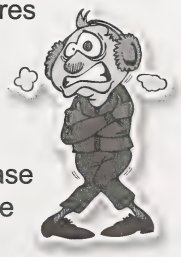
8. In which beaker (shown on page 86 of the textbook) would an ice cube melt faster? Explain why.

9. Answer "Reading Check" on page 86 of the textbook.

Check your answers on page106 of the Appendix.

Continue on page 86 of the textbook by reading "Did You Know?" The first sentence should actually say that heat cannot escape **easily** through a dog's thick coat. Mammals need ways to keep their body temperature within a fairly small range. During the summer, sadly, you hear of people who die from the summer heat. Their bodies were not able to cool themselves enough to stay in the survival temperature range. When body temperatures rise considerably above normal, it is known as **hyperthermia**. If not treated correctly and soon, the person will die. You also know the dangers of cold. When body temperatures fall much below normal, there is also a danger of death. This decrease in temperature is known as **hypothermia**. Again, the correct treatment is needed as soon as possible.





10. Answer questions 1 and 2 of "Check Your Understanding" on page 87 of the textbook.

Check your answers on page 107 of the Appendix.

Go to pages 3 and 4 of Assignment Booklet 2A and answer questions 7 to 12.

Lesson 3

Transfer of Heat

The two people beside the campfire are enjoying its warming flames. The guy with the wakeboard is getting warmed by the Sun. In both cases, heat is being transferred from one place to another with no direct contact between the people and the source of the warmth. In this lesson you will study three forms of heat transfer.

Find Out
Activity

Blending Water

Turn to page 87 of the textbook and read the entire activity.

You will be using hot and cold tap water to carry out this activity. The normal setting on most hot-water tanks gives hot water at about 50°C. This is done to protect people from scalding burns. You can use cups, mugs, or glasses instead of beakers. Try to use two containers that are alike for holding the hot and cold water. You might want to use a slightly larger container for the mixed water. If you didn't have metric measuring equipment, you can use 0.5 cup of each type of water instead of 100 mL. Also, using one thermometer is fine if that is all you have. If you use only one thermometer, wait a minute or so between temperature measurements.

Now, carry out the activity and answer the questions that follow.

Pay careful attention to the safety precautions mentioned.

1. Write a lab report for this activity. If needed, refer to the template given in "Investigation 5-A: Mysterious Motion" in Section 1: Lesson 1 of this Student Module Booklet.

2. Answer questions 1, 2, and 3 of "What Did You Discover?" on page 87 of the textbook.

CHECK Check your answers on pages 107 and 108 of the Appendix.

In the preceding activity, you found that the mixed water temperature was about halfway between the hot-water temperature and the cold-water temperature. This is the average of the two temperatures.

Turn to page 88 of the textbook and examine Figure 5.8. It shows an example of heat flowing from a hot object to a cooler one. Then, read the first paragraph of "Forms of Heat Transfer."

3. a. How would you know that heat is flowing from the hot object to the cool object in Figure 5.8?

   b. When heat flows from a hot object to a cooler object, how long will the heat flow?

Check your answers on page 108 of the Appendix.

Now, read the next three parts of "Forms of Heat Transfer" on pages 88 and 89 of the textbook. Here, you will read about **conduction**, **convection**, and **radiation**. These parts describe three different ways heat moves from one object to another.

4. How is heat transferred by conduction?

5. What is convection?

6. What two processes are involved in making the air above a red-hot stove element feel warm?

7. What is radiation?

8. How is radiation different from convection?

9. Study Figure 5.9 at the bottom of page 88 of the textbook.

   a. How does Figure 5.9 show heat transfer by conduction?

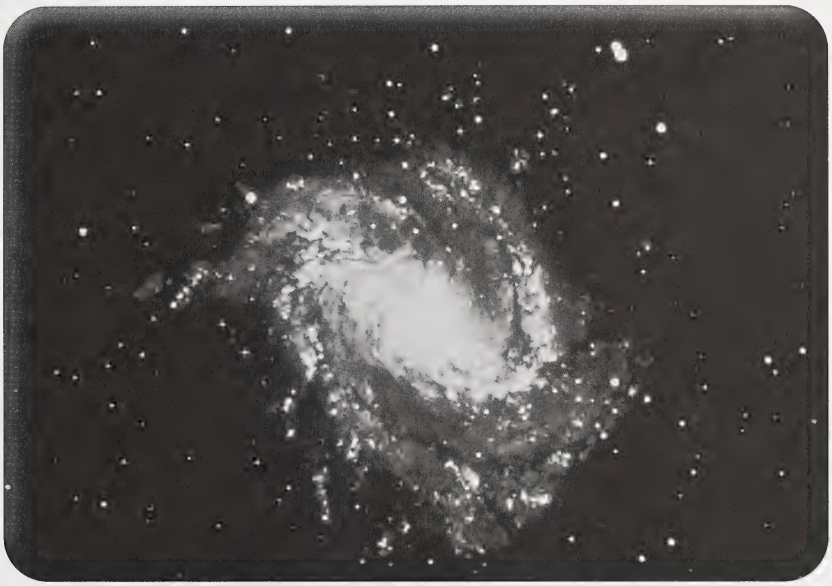
   b. How does Figure 5.9 show heat transfer by convection?

   c. How does Figure 5.9 show heat transfer by radiation?

Check your answers on page 108 of the Appendix.

Turn to page 89 of the textbook and read "Did You Know." If you are interested in more information, try the following website. It was prepared by a university professor who has made it quite "down-to-earth."

http://www.secondlaw.com/two.html



You may know that some objects feel colder than others in the winter. If you touch a piece of wood and a steel object when the surrounding temperature is –25°C, you know the steel object will feel colder than the piece of wood. To find out why this occurs, do the following investigation.

Investigation

5-B: Heat Conductivity Rate

Turn to pages 90 and 91 of the textbook and read the entire investigation.

This investigation requires equipment that is not readily available in the home. If you have access to a supervised laboratory and the heat conductivity apparatus, do **Part A**. If you do not have access to a supervised laboratory or the heat conductivity apparatus, do **Part B**.

Part A

Follow the procedure on pages 90 and 91 of the textbook carefully.

Pay special attention to the safety precautions mentioned.

10. Answer questions 1 and 2 of "Prediction."

11. Record your observations to Part 1 and Part 2.

12. Answer the following on page 91 of the textbook.

    a. questions 1 and 2 of "Analyze"

    b. questions 3 to 6 of "Conclude and Apply"

Check your answers on page 109 of the Appendix.

Part B

Using the following list of materials and apparatus, follow the steps of the procedure. You will test the heat conductivity of containers made of different material.

Materials and Apparatus:

- 3 or more containers of about the same shape and size made of different materials (e.g., a soup can with the label removed, a glass of about the same size, a Styrofoam™ cup)
- 2 or more cups of cold water (cooled in the refrigerator for 4 h or more)
- 125-mL (or 0.5-cup) measuring cup
- 3 or more small ice cubes (Refer to "Get Prepared" at the beginning of Lesson 2.)
- timing device (watch with a second hand)
- sink with 5 or 6 cm of hot tap water

Procedure:

step 1: Fill the sink with the hot tap water to a depth of 5 or 6 cm. **As with all hot substances, be careful around the sink filled with the hot water.**

step 2: Measure 125 mL (0.5 cup) of cold water into each of the containers.

step 3: Place one small ice cube in each container.

step 4: Place the containers with the cold water and ice into the sink.

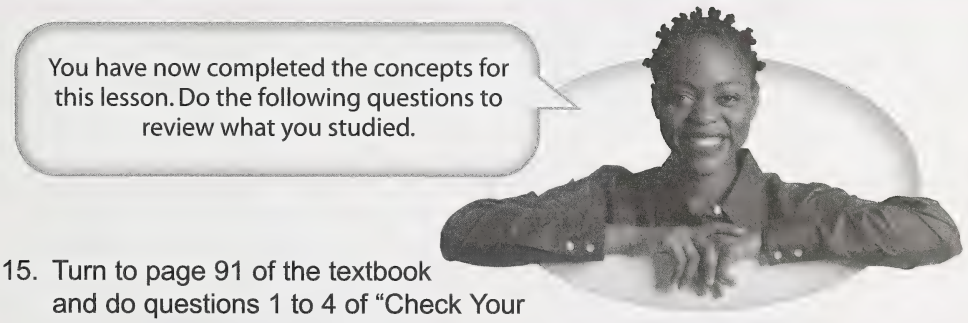
step 5: Determine how long it takes the ice cubes to melt. Stop timing when two of the containers no longer have ice in them. Record the time of the third container as longer.

step 6: Clean up the apparatus and work area.

13. What were the three containers you used made of?

14. Write appropriate observations and conclusion sections for this investigation.

Check your answers on page 110 of the Appendix.



15. Turn to page 91 of the textbook and do questions 1 to 4 of "Check Your Understanding."

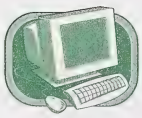
Check your answers on page 110 of the Appendix.

Go to pages 4 to 6 of Assignment Booklet 2A and answer questions 13 to 21.

Lesson 4

Heat Transfer in Nature

You can often tell if a furious storm is approaching by looking at the clouds. If they are tall and dark, it could even be a hailstorm. How does the water get into the clouds to later fall as rain or hail? On Earth, the Sun heats the ground. Moisture in the ground evaporates. It rises with the air that is heated by the hot ground. This natural heating of the air by convection leads to storm clouds. On the prairies, the moisture can rise beyond 8000 m. The tops of hail clouds can even go above 15 000 m. All of this is driven by heat being transferred.



You can learn more about hailstorms and attempts to control them at the following websites:

- **http://www.weathermod.com/alberta2.htm**
- **http://www.gi.alaska.edu/ScienceForum/ASF3/328.html**

Weather is often changing. A few days may be warm and sunny; then, cooler, windy, or rainy weather arrives. These changes are the result of heat transfer caused by convection.

Turn to page 92 of the textbook. Read the introduction to "Heat Transfer in Nature."

Investigation

5-C: Heat Convection in Liquids and Gases: Teacher Demonstration

Read over the investigation on pages 92 and 93.

1. Write a prediction for this investigation.

Check your answer on page 111 of the Appendix.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory or if your lab does not have all the necessary equipment, do **Part B**.

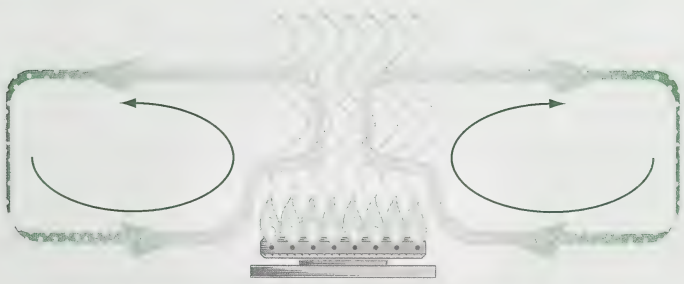
Part A

Follow the procedure carefully and complete the investigation. **Pay special attention to the safety precautions mentioned.**

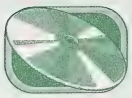
2. Answer the following on page 93 of the textbook.

   a. questions 1 to 5 of "Analyze"
   b. questions 6, 7, and 8 of "Conclude and Apply"
   c. questions 9 and 10 of "Extend Your Knowledge"

Check your answers on page 111 and 112 of the Appendix.



Part B



You are going to observe a demonstration of convection that is similar to Investigation 5-C in the textbook. Insert the *Science 14 Multimedia CD* into your computer. View the segment "How Convection Works."

3. What happens to the potassium permanganate at the start of the demonstration?

4. Compare the size of the convection cycle when the water is just starting to warm up to that of when the water in the tank has warmed up.

5. The major method through which heat is transferred in liquids (fluids) and gases is _____.

6. Heat is transferred in solids through _____.

7. Which form of heat transfer involves wave-like forms transmitted from the heat source?

8. In what direction from the heat source are the wave-like forms transmitted?

9. Use your understanding of convection in the water tank to answer the following on page 93 of the textbook.

   a. questions 6 and 8 of "Conclude and Apply"

   b. question 9 of "Extend Your Knowledge"

   c. Predict what will happen to the smoke in the gas convection apparatus in Part 2 of Investigation 5-C.

10. Answer the following on page 93 of the textbook.

    a. questions 3, 4, and 5 of "Analyze"

    b. question 7 of "Conclude and Apply"

    c. question 10 of "Extend Your Knowledge"

Check your answers on page 112 of the Appendix.

Now that you have an understanding of convection in fluids, turn to page 93 of the textbook. Read "Convection Currents and Weather" near the bottom of the page. Then read "Sea and Land Breezes" on pages 94 and 95. These are two examples of large convection currents.

11. List the steps that produce a sea breeze, and make a sketch of a sea breeze.

12. Describe the motion of the air in a land breeze.

13. Why is a land breeze weaker than a sea breeze?

14. Explain why it is warm to sit in front of a cottage at the lake on a calm evening after a warm day.

15. Which way does the air flow in a mountain breeze?

Check your answers on page 113 of the Appendix.

You have seen that bodies of water can create breezes both during the day and at night. In the next investigation you will analyze how large bodies of water affect climate of nearby land masses.

Turn to page 96 of the textbook and read through Investigation 5-D: How Oceans Affect Climate." Notice the different materials you will need—a map of Canada, a map of the world, and graph paper—to complete this investigation. You will have to create four graphs.

Creating a Graph

Here is a quick review of how to build a bar graph. The following steps were used to graph the first column of the table in "Investigation 5-D."

step 1: Title the graph.

> The title can be the title of the data column with some additional information. For example, the title of this graph will be "Mean January Temperatures for Five Canadian Cities."

step 2: Label the axes.

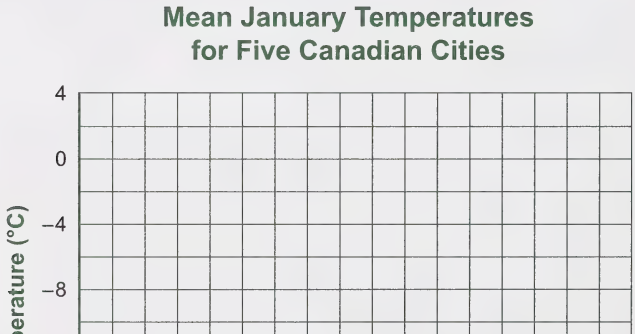
The vertical axis displays the dependent data. Because temperature depends on the city, the label for the vertical axis will be "Temperature (°C)." The horizontal axis displays the independent data. In this case, the independent data is the city. Therefore, the label of the horizontal axis will be "City."

step 3: Choose the range of values for both axes (if needed).

For the vertical axis (temperature), the lowest value is –18 and the highest value is 2. Generally, you want to leave a little room at the top and bottom of the graph. So, in this case, the vertical axis will range from –20°C to 4°C and will increase in increments of 2°C.

For the horizontal axis, there are no numerical values in this case. The horizontal axis will have the names of the city for which the data corresponds. Choose an order that makes sense to you. For example, the cities could be placed in the order in which they were displayed, in alphabetical order, or in geographical order from west to east. In this case, the cities will be labelled in the order they appear in the table.

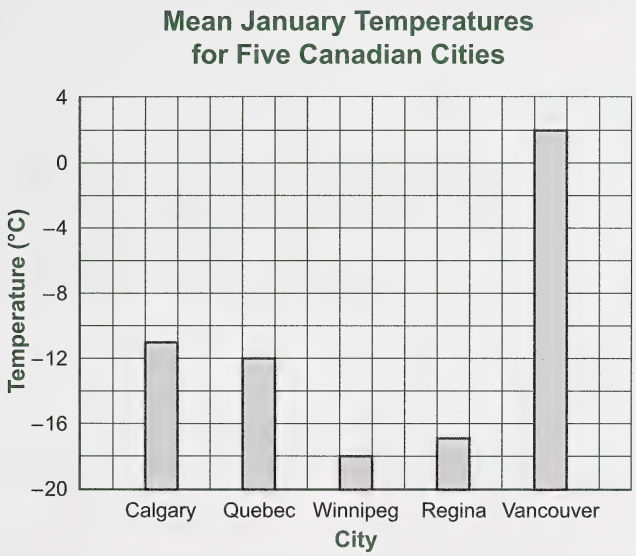
Here is what the graph will look like at this point.



step 4: Graph the data.

Mark the tops of each bar at the position of the given temperature. For example, draw a line at −11°C for Calgary. Then complete the bar, and colour the bar as desired.

The completed graph should look like the following.



16. Now, complete "Investigation 5-D: How Oceans Affect Climate." Do questions 1, 2, and 3 of "What to Do" on page 96 of the textbook. Follow the steps outlined when building the graphs. **Note:** For question 3, the first graph has already been done for you.

17. Answer the following on page 96 of the textbook.

    a. questions 1 and 2 of "Analyze"

    b. question 3 of "Conclude and Apply"

CHECK Check your answers on pages 113 to 116 of the Appendix.

Turn to page 97 of the textbook and read "How Oceans Help to Moderate Climates."

18. How does an ocean moderate climate in cool weather?

19. How does an ocean moderate climate in hot weather?

20. How is convection involved here?

21. Answer "Reading Check" on page 97 of the textbook.

22. Complete textbook questions 1, 2, and 3 of "Check Your Understanding" on page 97 of the textbook.

CHECK Check your answers on pages 116 and 117 of the Appendix.

Go to ... Go to pages 6 to 8 of Assignment Booklet 2A and answer questions 22 to 30.

Lesson 5

Heat Transfer and Technologies

An explosion creates convection currents. It pulls dust and other ground materials up into the fireball. This creates the characteristic mushroom-shaped cloud of an atomic explosion. An atomic explosion is an extreme example of people using heat transfer. In day-to-day life, a hot stove or a refrigerator are more likely to provide the heat transfer people are interested in. In this lesson you will study how heat transfer is used in daily life.

Do you know tea drinkers who always preheat the teapot before making tea? To find out why, read "Heat Transfer and Technologies" on pages 98 and 99 of the textbook. This reading explains how all three forms of heat transfer are used in preparing meals.

1. Use ideas of heat transfer to explain the purpose of having a plastic or wooden handle on a cooking pot.

2. Through which heat transfer method is soup in a pot heated at first?

3. Why does a cook often stir a pot of soup after it has been heating for a few minutes?

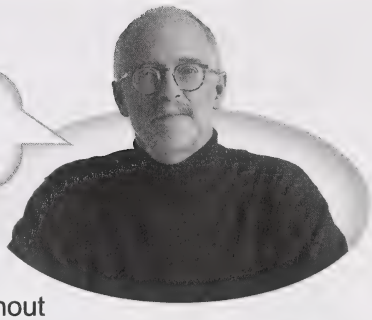
4. What methods of heat transfer are involved in transferring heat when an oven is used to cook food?

5. Answer "Reading Check" on page 99 of the textbook.

CHECK

Check your answers on page 117 of the Appendix.

Read "Did You Know?" and the caption in Figure 5.16 on page 99 of the textbook.



6. Why are metal cooking pots used throughout the world? **Hint:** Your work with conductivity in Lesson 3 should help explain their popularity.

7. In the introduction to Lesson 3, the guy with the wakeboard is wearing a black wetsuit. How will his wetsuit benefit him after he comes out of the water on a sunny day?

CHECK Check your answers on page 118 of the Appendix.

Read through "Career Connect" on page 99 of the textbook.

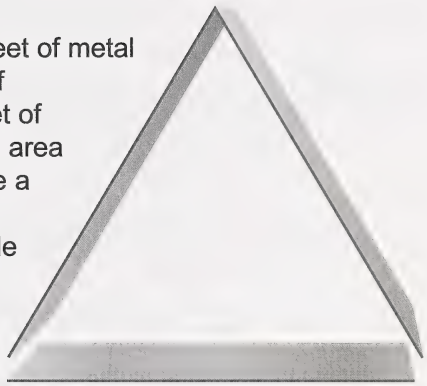
Firefighters are not the only workers who need to know about heat transfer. Turn to page 100 to see another heat transfer situation. Read "Getting Rid of the Heat."

8. What is the purpose of a radiator on a motor vehicle?

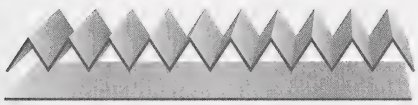
9. What method of heat transfer is used in a motor vehicle radiator?

CHECK Check your answers on page 118 of the Appendix.

Now try this thought experiment. Think of a sheet of metal that is 50 cm by 50 cm. It has a surface area of (50 x 50) cm^2 = 2500 cm^2. Now, think of a sheet of metal that is 100 cm by 50 cm. It has a surface area of (100 x 50) cm^2 = 5000 cm^2. Can you imagine a way to fold it so it would sit exactly on the first sheet but still have all the surface area available to the air? Using only one fold would work, but it would take up a large amount of space.



Can you think of a way that would reduce the amount of space it takes without reducing its surface area? One way would be to fold it as shown here. It is a side view of the sheets of metal.



10. Which one of the sheets of metal shown would be able to get rid of heat faster? Why?

Check your answer on page 118 of the Appendix.

This increase in surface area idea is used regularly to get rid of heat. If you look closely at a radiator, you will see that it has a large surface area. Yet, it is fairly compact. If you look at the motorcycle engine, you will, again, see the same idea used. If you need more cooling, increase the surface area. (You can also increase the airflow and many other things to remove more heat.)

11. In addition to using a large surface area in the radiator, how does a vehicle cooling system cool a motor? (**Hint:** What other item is used along with a radiator as part of a vehicle cooling system?)

12. How does an air-cooled engine keep from overheating?

Check your answers on page 118 of the Appendix.

Now, turn to page 101 of the textbook and read "Keeping It Cool." Be sure you read the five steps of heat transfer in a refrigerator. In step E you see, yet again, the use of increased surface area. There is a large array of copper tubing and metal fins. This gives the heat in the compressed coolant more contact with air and allows it to transfer into the room more efficiently.

13. You may recall running through a lawn sprinkler on a hot day when you were younger. How does water on your body cool you off?

14. Where does thermal energy from food first pass to in a refrigerator?

15. When does the coolant in a refrigerator evaporate?

16. What is the purpose of the compressor in a refrigerator?

17. Where does the heat from food in a refrigerator go to in the end?

Check your answers on page 118 of the Appendix.

Did you know?

Did you know that it takes more energy to convert 1 g of water from liquid to gas than to melt 1 g of ice and raise it to boiling point? Check out the following figures:

- 334 J to melt 1 g of ice at 0°C
- 418.6 J to raise 1 g of water from 0°C to 100°C
- 2256 J to change 1 g of boiling water to steam at 100°C

18. a. What is the total amount of energy needed to convert 1 g of ice to water and raise the temperature of the water to 100°C?

    b. How many times more energy is needed to convert 1 g of boiling water to steam than to melt 1 g of ice and raise the temperature of the water to 100°C?

19. Complete questions 1 to 4 of "Check Your Understanding" on page 101 of the textbook.

CHECK Check your answers on page 119 of the Appendix.

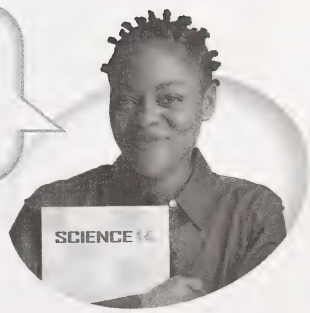
Go to ... Go to pages 8 and 9 of Assignment Booklet 2A and answer questions 31 to 36.

Section 1 Review

In this section you studied heat and the transfer of heat. You studied how the molecular theory of heat was developed. You learned the difference between heat and temperature and experimented with heat transfer. You saw how the molecular theory explains heat transfer and you looked at how heat transfers in nature affect climate. You also examined how people use heat transfers to enhance the enjoyment in their lives.

The ideas you have learned about heat transfer apply to many everyday items that you use. Now, you understand why some pots have wooden or plastic handles and why some have copper on the bottom.

You have now completed the concepts for this section. To review what you covered, answer the questions that follow. If needed, go back and read over parts of this section while you answer the questions.



1. Complete the following word search. It involves important people and terms from this section.

BROWNIAN MOTION
CONDUCTION
CONVECTION
COUNT RUMFORD
FRICTION
HEAT
HYPERTHERMIA
HYPOTHERMIA
JOULE
KINETIC ENERGY
LAND BREEZE
LAVOISIER
MODERATE
RADIATION
ROBERT BROWN
SEA BREEZE
TEMPERATURE
THERMAL ENERGY

N	Y	L	E	H	Y	P	O	T	H	E	R	M	I	A
O	G	G	H	Y	C	B	W	X	M	R	O	E	E	B
I	R	C	R	P	O	E	N	H	W	U	B	Z	T	P
T	E	U	A	E	U	Z	O	O	E	T	E	E	A	M
O	N	G	D	R	N	E	I	O	F	A	R	E	R	F
M	E	K	I	T	T	E	T	N	R	R	T	R	E	I
N	L	F	A	H	R	R	C	O	I	E	B	B	D	R
A	A	K	T	E	U	B	E	I	C	P	R	A	O	L
I	M	C	I	R	M	D	V	T	T	M	O	E	M	H
N	R	Q	O	M	F	N	N	C	I	E	W	S	W	Y
W	E	S	N	I	O	A	O	U	O	T	N	A	Y	Z
O	H	L	E	A	R	L	C	D	N	S	B	I	C	H
R	T	D	U	Q	D	N	U	N	B	O	I	A	K	M
B	S	O	A	O	L	A	V	O	I	S	I	E	R	K
R	L	Z	D	Y	J	G	Y	C	D	D	P	J	K	M

2. Answer the following "Chapter 5 Review" questions on pages 102 and 103 of the textbook.

   a. question 1 of "Reviewing Key Terms"

   b. questions 4 and 6 of "Understanding Key Ideas"

   c. questions 9 and 10 of "Problem Solving/Applying"

Check your answers on pages 120 and 121 of the Appendix.

Section 2

CONTROLLING HEAT TRANSFER

While there are no nuclear power plants in Alberta, they do provide power in many parts of the world. Nuclear power plants are an example of controlling heat transfer. The major difference between the atomic bomb and a nuclear reactor is control. In an atomic bomb, the idea is to unleash as much energy as possible and as rapidly as possible. In a nuclear reactor, the idea is to release a controlled amount of energy for a long period. In this section you will study how to control the transfer of heat energy.

Turn to pages 104 and 105 of the textbook. Read the introduction to "Chapter 6: Controlling Heat Transfer." Pay particular attention to "What You Will Learn," "Why It Is Important," and "Skills You Will Use." These parts give you a quick overview of the material you will be covering.

Lesson 1

Absorbing and Losing Heat

Have you gone to the beach and nearly burnt your feet due to the hot sand? Did you go into the water to cool your feet? Why is the sand hotter than the water? In this lesson you will learn about substances absorbing and losing heat.

Starting Point Activity

Survivor

Read through the activity on page 105 of the textbook. Think carefully about the task it is suggesting. Think about the materials you have on hand.

1. Why would you want shoes when you are stranded on a tropical beach?

Check your answer on page 121 of the Appendix.

Carry out steps 1 and 2 of "What To Do." Save the results in your notebook. As you work through Lessons 1, 2, and 3, come back to your design and apply the things you learn to building better footwear.

Investigation

6-A: Keeping It Cool

Turn to pages 106 and 107 of the textbook and read the entire investigation.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

Part A

Follow the steps of the procedure carefully. **Pay special attention to the safety precautions mentioned, especially the one regarding hot substances and the dangers of oil and a hot plate.**

2. Record your observations for Part 1 and Part 2 in tables like the following.

PART 1: LIQUIDS

Substance	Starting Temperature (°C)	Finishing Temperature (°C)	Time Taken to Raise the Temperature 30°C
water			
motor oil			
vegetable oil			

PART 2: SOLIDS

Substance	Starting Temperature (°C)	Finishing Temperature (°C)	Time Taken to Raise the Temperature 30°C
glass marbles			
sand			
iron shot or nails			

3. Answer the following on page 107 of the textbook.

   a. questions 1 to 4 of "Analyze"

   b. question 5 of "Conclude and Apply"

Check your answer on page 122 of the Appendix.

Part B

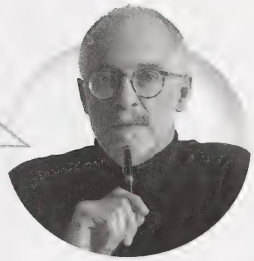
Use the following data to answer question 3 in Part A. It is from a student who completed Investigation 6-A.

PART 1: LIQUIDS

Substance	Starting Temperature (°C)	Finishing Temperature (°C)	Time Taken to Raise the Temperature 30°C
water	21°C	51°C	4 min 59 s
motor oil	21°C	51°C	2 min 50 s
vegetable oil	21°C	51°C	2 min 36 s

PART 2: SOLIDS

Substance	Starting Temperature (°C)	Finishing Temperature (°C)	Time Taken to Raise the Temperature 30°C
glass marbles	21°C	51°C	2 min 20 s
sand	21°C	51°C	2 min 0 s
iron shot or nails	21°C	51°C	1 min 48 s


The investigation you just completed showed that substances absorb different amounts of heat. This was shown by how much time each substance took to increase in temperature.

Turn to pages 108 and 109 of the textbook and read "Specific Heat Capacity." This section describes the **specific heat capacity** of substances. This is related to everyday occurrences. For example, it explains the situation in the cartoon on page 106. The Sun raises the temperature of the sand much more quickly than the temperature of the water. The energy needed to raise 1 g of water 1°C will raise the temperature of 1 g of sand by more than 6°C. Does this surprise you?

There are three factors that affect the amount of energy absorbed by an object:

- the specific heat capacity of the substance
- how much the temperature rises
- the amount of material

Example

How much energy is needed to raise 1 g of water 4°C?

Solution

The chart on page 109 of the textbook gives the specific heat capacity of some common materials. The specific heat capacity of water is 4.19 J/g•°C. This example asks about raising the temperature 4°C. The specific heat capacity is given for a 1°C temperature increase. The water in the example will, therefore, require 4 times as much energy.

1°C temperature rise = 4.19 J

∴ 4°C temperature rise = 4 x 4.19 J
= 16.76 J

To raise the temperature of 1 g of water 4°C, 16.76 J of energy is needed.

Example

How much energy is needed to raise 5 g of water 1°C?

Solution

The specific heat capacity of water is 4.19 J/g•°C. This value is for 1 g of water. The question asks about 5 g of water. This is 5 times as much water. Therefore, this will require 5 times the amount of energy.

Raise 1 g of water 1°C = 4.19 J

∴ Raise 5 g of water 1°C = 5 x 4.19 J
= 20.95 J

To raise the temperature of 5 g of water 1°C, 20.95 J of energy is needed.

4. How much energy is needed to make the following temperature changes? Show your work for each part.

   a. raising 1 g of water 10°C

   b. raising 1 g of water 25°C

   c. raising 1 g of glass 10°C

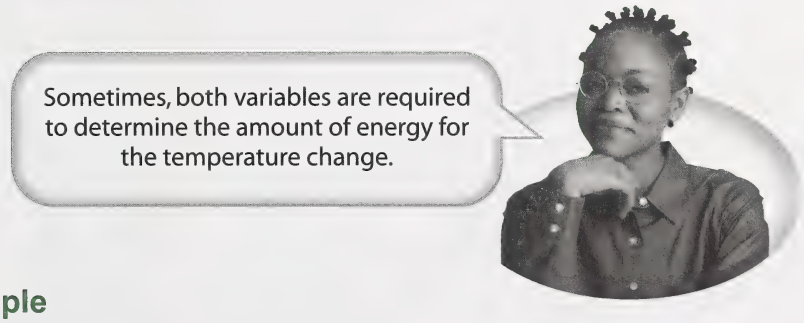
5. How much energy is needed to make the following temperature changes? Show your work for each part.

   a. raising 10 g of water 1°C

   b. raising 35 g of water 1°C

   c. raising 20 g of glass 1°C

Check your answers on page 123 of the Appendix.



Example

How much energy is needed to raise the temperature of 10 g of copper by 5°C?

Solution

The specific heat capacity of copper is 0.38 J/g•°C.

Raise 1 g of copper 1°C = 0.38 J

∴ Raise 10 g of copper 1°C = 10 x 0.38 J
= 3.8 J

∴ Raise 10 g of copper 5°C = 5 x 3.8 J
= 19 J

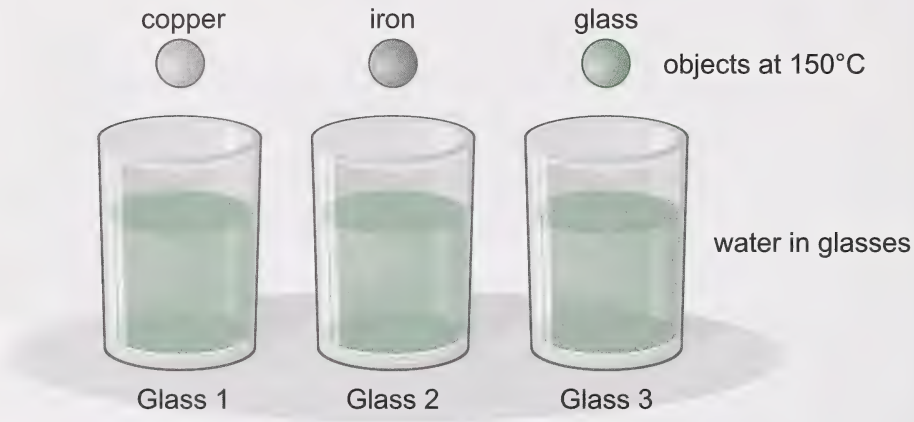
To raise 10 g of copper 5°C, 19 J of energy is needed.

6. How much energy is needed to make the following temperature changes for the given amount of the substance?

   a. raising 5 g of motor oil 10°C

   b. raising 2 g of glass 5°C

7. a. Pieces of copper, iron, and glass, each with a mass of 10 g, are placed in an oven. The oven heats the pieces to 150°C. Three glasses with 100 mL of water at the same temperature are prepared. One piece is dropped into each glass.



   Which glass will end up with the highest temperature? Explain why.

   b. The same pieces of copper, iron, and glass are reheated to 150°C and dropped into glasses of vegetable oil labelled 1, 2, and 3. Which glass will end up with the highest temperature?

   c. Will the final temperature of the water and the oil be the same if the starting temperatures were the same?

Check your answers on page124 of the Appendix.

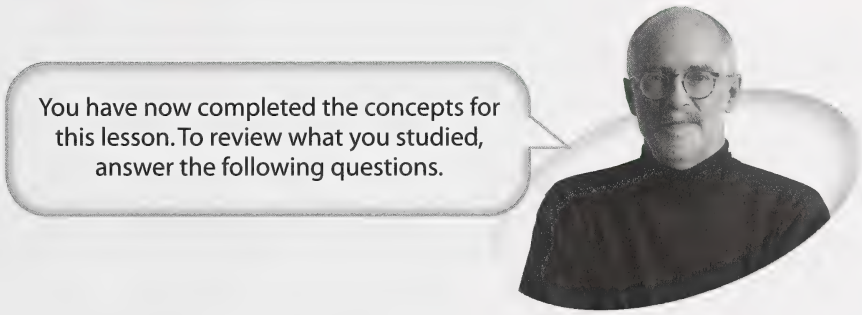
Turn to pages 109 and 110 of the textbook and read "Warming Up and Cooling Down with Oceans." You will see another reason for the moderating effect of oceans on nearby cities.

8. Which has a higher heat capacity—land or water?

9. Which heats quicker and cools quicker—land or water?

10. How does water affect climate?

CHECK Check your answers on page 124 of the Appendix.



11. Answer questions 1 to 4 of "Check Your Understanding" on page 110 of the textbook.

12. What is the substance above the spout that you see when a kettle is boiling?

CHECK Check your answers on pages 124 and 125 of the Appendix.

Go to ... Go to pages 1 to 3 of Assignment Booklet 2B and answer questions 1 to 9.

Lesson 2

Keeping Heat at Home

Watching the progress of a new house being built can be very interesting. You can imagine what it will look like when it is all finished. As a house is being built, one of the main concerns of a homeowner is paying big heating bills in the winter. Are the workers putting in an unbroken vapour barrier? Is there a lot of insulation being installed? Are there vents in the attic? All of these things can help keep the heating bills down.

Turn to page 111 of the textbook. Read the introductory paragraphs of "Keeping Heat at Home"; then read "R-value." When people talk about insulation in houses, you will hear terms like *R-12* or *R-20* used quite often.

1. What is the material used to reduce heat loss in buildings called?

2. Insulation in a building keeps heat _____ during the winter and keeps heat _____ during the summer.

3. Define the term *R-value*.

CHECK Check your answers on page 125 of the Appendix.

Here is an interesting Internet site about insulation in the home:

http://www.physicscentral.com/lou/lou-02-04.html

Now, study the example on page 111 of the textbook. You will see that more insulation is better at blocking heat transfer. You will see that the R-values add together. The example uses the values in the chart at the bottom of the page.

4. What is the R-value of 25 mm of fibreglass insulation and 25 mm of solid wood?

Check your answer on page 125 of the Appendix.

Investigation

6-B: Ice Sculptures

You can compare the insulating value of substances by testing various types of insulation. Turn to pages 112 and 113 of the textbook and read over the entire investigation.

5. Write your prediction for the order of the insulating materials from best to poorest.

Check your answer on page 125 of the Appendix.

If you have access to a supervised lab or if you can obtain the required materials and have a kitchen scale, do **Part A**. If you do not have access to the materials, do **Part B**.

Part A

Follow the steps of the procedure. **Pay attention to the safety precautions mentioned. Be careful with poured insulation if it is fibreglass. It can irritate the skin. Also avoid creating and inhaling dust from poured insulation. A dust mask should be used when handling the insulation.**

6. Copy and complete a table similar to the one on page 113 of the textbook.
7. Answer the following on page 113 of the textbook
   a. questions 1 to 4 of "Analyze"
   b. questions 5 and 6 of "Conclude and Apply"
   c. question 8 of "Extend Your Knowledge"

Check your answers on pages 126 and 127 of the Appendix.

Part B

Review the procedure on pages 112 and 113 of the textbook carefully so you understand what is to be done in this investigation. Once you have a good idea as to what is being done, use the following table to answer question 7 in Part A.

Insulation Material	Ice Cube Initial Mass (g)	Ice Cube Final Mass (g)	Ice Cube Mass Lost (g)
wood shavings	68	52	16
foam pellets	66	56	10
bubble wrap	69	55	14
poured insulation	68	57	11
aluminum foil	67	47	20
empty can	68	46	22

Find Out
Activity

Will Aluminum Foil Keep You Warm?

Turn to page 114 of the textbook and read the entire activity.

Complete this activity by following the step in "What to Do." If you are doing this activity at home, use water that is between 45°C and 50°C so you can use an ordinary outdoor thermometer to measure its starting temperature. Use two identical glasses and fill them to the same level.

8. Complete a table like the following.

Glass	Starting Temperature	Temperature After 30 min
glass only		
glass with aluminum foil wrap		

9. Answer questions 1 and 3 of "What Did You Find Out?" on page 114 of the textbook.

CHECK Check your answers on page 127 of the Appendix.

As an extension to this activity, compare the shiny and dull sides of the aluminum foil. Have the foil so its shiny side is facing in on one glass and facing out on the other.

10. What do you notice about the temperature of the water in each container after 30 min?

CHECK Check your answer on page 128 of the Appendix.

Continue on pages 114 and 115 of the textbook by reading "Other Ways to Keep the Heat in Your House" and "Windows and Doors That Keep Heat In." You will notice that heat is hard to keep inside. You have to work at blocking convection, conduction, and radiation.

With the price of energy rising, conserving energy can save building owners a significant amount of money. Read through "Investigation 6-C: Energy Efficiency" on page 116 of the textbook. In place of your school, you can carry out an energy audit on your home. (Look for places where energy could be saved.) Do you think you can find ways to save on energy bills in your house?

Here is an Internet site that shows ways of improving energy efficiency:

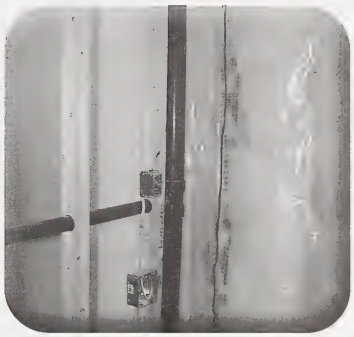
http://www.diynet.com/DIY/article/0,2058,7260,00.html

Be sure to check out some of the other heat-saving projects listed at the bottom of the webpage.

11. List three things you could do to save energy around your home.

12. Why do builders put insulation in large hollow spaces in walls?

Check your answers on page 128 of the Appendix.



When you are making suggestions about ways to decrease energy loss, you often want to add more insulation. You need to know how much insulation is enough. The R-values for different substances given in the table on page 111 of the textbook can help. Often, you will have to use different types of insulation on the same project. Sometimes you even use different types at the same place. With insulation, more is often better; but you have to have room for it. If you need R-15 and only have 50 mm of space, you can only put in 50 mm of insulation. If you compress 75 mm of fibreglass insulation into a 50 mm space, you will still only have the R-value for 50 mm of fibreglass insulation.

The following examples show you how to determine the R-value of different thicknesses of insulation and different combinations of materials and insulation.

Example

Find the R-value of each of the following amounts of insulation.

a. 100 mm of fibreglass insulation

b. 50 mm of expanded polystyrene

c. 100 mm of clay brick

Solution

a. The R-value of 25 mm of fibreglass insulation is 4.25. Because 100 mm is 4 times as much as 25 mm (100 ÷ 25 = 4), the R-value of 100 mm will be 4 times larger.

   4 x 4.25 = 17

   The R-value of 100 mm of fibreglass insulation is 17.

b. The R-value of 25 mm of expanded polystyrene is 3.96. Because 50 mm is 2 times as much as 25 mm (50 ÷ 25 = 2), the R-value of 50 mm will be 2 times larger.

   2 x 3.96 = 7.92

   The R-value of 50 mm of expanded polystyrene is 7.92.

c. The R-value of 25 mm of clay brick is 0.11. Because 100 mm is 4 times as much as 25 mm, the R-value of 100 mm will be 4 times larger.

4 x 0.11 = 0.44

The R-value of 100 mm of clay brick is 0.44.

Example

Find the R-value of each of the following combinations of insulation.

a. 100 mm of wood shavings plus 50 mm of clay brick

b. 25 mm of air space plus 25 mm of rigid urethane foam plus 100 mm of concret

Solution

a. This question has two insulators: wood shavings and clay brick.

First, find the R-value of the wood shavings alone.

The R-value of 25 mm of wood shavings is 2.42. Because 100 mm is 4 times as much as 25 mm, the R-value of 100 mm will be 4 times larger.

4 x 2.42 = 9.68

The R-value of 100 mm of wood shavings is 9.68.

Second, find the R-value of the clay brick alone.

The R-value of 25 mm of clay brick is 0.11. Because 50 mm is 2 times as much as 25 mm, the R-value of 50 mm will be 2 times larger.

2 x 0.11 = 0.22

The R-value of 100 mm of clay brick is 0.22.

Now, find the total R-value by adding the values found for the wood shavings and the clay brick together.

Wood shavings + Clay brick = 9.68 + 0.22
= 9.90

The total R-value is 9.90.

b. This question has three insulators: air space, rigid urethane foam, and concrete.

The R-value of 25 mm of air space is 2.04.

The R-value of 25 mm of rigid urethane foam is 7.50.

Find the R-value of 100 mm of concrete.

The R-value of 25 mm of concrete is 0.19. Because 100 mm is 4 times as much as 25 mm, the R-value of 100 mm will be 4 times larger.

4 x 0.19 = 0.76

The R-value of 100 mm of concrete is 0.76.

Now, find the total R-value by adding the values found for the air space, urethane foam, and concrete.

Air space + Rigid urethane foam + Concrete = 2.04 + 7.50 + 0.76
= 10.30

The total R-value is 10.30.

Read the "Off the Wall" box at the bottom of page 116 of the textbook. You can get another way of understanding of R-value from it.

13. Calculate the R-value for the following combination of insulation and building materials.

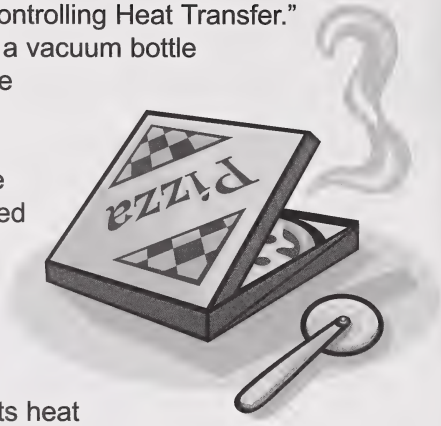
    a. 25 mm of air space with reflective surface plus 50 mm of rigid urethane foam

    b. 12.5 mm of solid wood plus 150 mm of fibreglass

14. What fraction of heat does insulation with an R-value of 30 allow to pass?

Check your answers on pages 128 and 129 of the Appendix.

Turn to page 117 of the textbook and read "Controlling Heat Transfer." You will learn how to keep pizza hot and how a vacuum bottle works. Both are based on preventing the three methods of heat transfer.



15. What material do you think is used on the inside of the insulating layer of an insulated envelope used to deliver pizza?

16. Answer the following questions about vacuum bottles.

    a. Which part of a vacuum bottle prevents heat transfer by conduction?

    b. Which part of a vacuum bottle prevents heat transfer by convection?

    c. Which part of a vacuum bottle prevents heat transfer by radiation?

Check your answers on page 129 of the Appendix.

Turn to page 119 of the textbook and read "Kitchen and Workshop." Study how the prevention of heat transfer is used at home and at work.

17. Why is plastic a common insulating material used on kitchen appliances?

18. Why do you want a freezer that has walls that are well insulated?

19. Answer questions 1 to 6 of "Check Your Understanding" on page 119 of the textbook.

Check your answers on pages 129 and 130 of the Appendix.

Go to pages 3 to 5 of Assignment Booklet 2B and answer questions 10 to 16.

Lesson 3

Keeping Yourself Warm

You often think of a bright sunny day as being hot. The pictures above show that this is not always true. In Canada's climate, especially in the arctic, the Sun doesn't always provide enough energy to make the day hot. You have to dress in a manner that keeps you warm.

Turn to page 120 of the textbook. Read the introductory paragraph of "Keeping Yourself Warm." You should see how your study of insulation for houses can be applied to clothing.

1. Answer the question posed in Figure 6.10 for each of the items labelled in the picture.

2. Why is it important to wear more than one layer of clothing in cold weather?

3. What type of clothing do you want next to your body? Why?

CHECK Check your answers on page 131 of the Appendix.

Continue by reading "People of the North" on page 121 of the textbook. You will see that the same heat-saving ideas have been used in the traditional clothing worn in Canada's north.

4. Why do Caribou Inuit wear the inner suit with the fur turned to the inside?

5. Why do Caribou Inuit wear the outer suit with the fur turned to the outside?

6. What special features of caribou fur make it especially good for warm clothing?

7. What benefit is the large hood with the fur trim around the edge?

8. Why do Caribou and Copper Inuit wear seal skin boots as the outer layer on their feet?

CHECK Check your answers on page 131 of the Appendix.

For more information on clothing that people of the north wear, visit the website given in "Internet Connect" on page 121 of the textbook. If you wish, complete the questions in Part D of the Worksheet: ICT 6-1, *Surviving the Arctic.* (There is a link to the worksheet on the webpage referenced.) Place your answers in your notebook.

Investigation

6-E: A Winter Survival Car Kit

Turn to page 122 of the textbook and read the entire investigation.

Complete the investigation as outlined in "Design Criteria" and "Plan and Construct." If you have Internet access, do "Internet Connect" as a check on your safety kit.

9. Answer questions 1 to 5 of "Evaluate."

Check your answers on page 132 of the Appendix.

Turn to page 123 of the textbook and read the two paragraphs of "Keeping Cool." Closely examine the picture on the page. Would you expect that a hot summer day is shown in the picture? The next activity should help you answer that question.

Find Out Activity

Is Heat Transfer a Black and White Issue?

Read over the entire activity on page 123 of the textbook. Complete the activity by following the instructions in "What to Do." If you don't have two thermometers, change the activity by doing the white sock first, then the black sock. Make sure that each sock gets the same amount of time in the Sun.

10. Answer questions 1 to 5 of "What Did You Find Out?"

11. Why might light-coloured shingles be preferred to black shingles for a summer cabin?

12. Why might some house construction contractors refuse to put black or dark-coloured asphalt shingles on a house they are building?

Check your answers on page 132 of the Appendix.

Turn to pages 124 and 125 of the textbook. Read the section titled "Dressing for Intense Heat—or Cold." Pay attention to the information given in "Did You Know?" It gives a little more information about keeping warm in cold water.

13. What is used to make a firefighter's suit so it does not burn easily?

14. How can a firefighter suffer heat stroke in the winter?

15. How do scientists test firefighter clothing?

16. Why should a diver's suit fit snugly?

17. What materials are dive suits made from?

18. What is the purpose of adding titanium to the fabric on the inside of a diver's suit?

Check your answers on pages 132 and 133 of the Appendix.

You have just completed the concepts for this lesson. To review what you covered, do the following questions.

19. Answer questions 1 to 6 of "Check Your Understanding" on page 125 of the textbook.

CHECK Check your answers on pages 133 and 134 of the Appendix.

Go to ... Go to pages 6 and 7 of Assignment Booklet 2B and answer questions 17 to 23.

Section 2 Review

In Section 2 you learned about controlling heat transfer. You examined the differing heat capacities of different substances and identified three ways heat can be transferred. You described how homebuilders can prevent heat loss or gain by applying their knowledge of heat transfer. This led to the study of the R-values of several insulating materials. You identified some insulating properties of different types of clothing, and you described how the Aboriginals of Canada's north use materials at hand to make warm clothing.

What you learned in this section can help you determine what you need to do to control heat transfer in several everyday applications. Do you know what clothing is best to wear if you are planning to walk outside on a cold, winter day?

You have now completed the concepts for this section. To review what you studied, answer the questions that follow. Feel free to read over part of this section while you answer the questions.

1. Complete the following word search.

CARIBOU
EFFICIENCY
HEAT ABSORPTION
INSULATION
LAYER
NEOPRENE
R-VALUE
SEAL SKIN
SPECIFIC HEAT
STEAM
THERMOMETER
TITANIUM
VACUUM BOTTLE
WOLVERINE
WOOL

N	E	O	P	R	E	N	E	B	S	M	A	A	P	P
E	O	T	C	T	G	Z	L	F	W	T	D	R	O	R
F	I	I	O	J	T	W	M	O	C	V	R	Q	S	X
F	U	T	T	I	H	A	T	R	V	A	L	U	E	N
I	P	A	S	P	E	C	I	F	I	C	H	E	A	T
C	U	N	P	T	R	P	W	J	N	U	R	Y	L	V
I	B	I	S	C	M	O	T	Y	S	U	N	Z	S	V
E	O	U	W	H	O	F	S	W	U	M	B	I	K	R
N	R	M	C	L	M	Z	I	B	L	B	I	O	I	W
C	I	L	A	Y	E	R	G	W	A	O	P	G	N	Y
Y	C	M	R	D	T	M	B	R	T	T	Z	H	I	C
Q	U	L	I	L	E	E	Q	O	I	T	A	V	P	E
I	L	H	B	E	R	T	K	A	O	L	I	E	Z	Q
Q	Z	W	O	L	V	E	R	I	N	E	D	X	H	F
K	U	G	U	I	T	S	E	K	Q	H	I	M	H	Y

2. Answer the following "Chapter 6 Review" questions on pages 126 and 127 of the textbook.

   a. question 1 of "Reviewing Key Terms"

   b. questions 2 to 5 of "Understanding Key Ideas"

   c. questions 8 and 10 of "Problem Solving/Applying"

   d. questions 13, 14, and 15 of "Critical Thinking"

Check your answers on pages 135 and 136 of the Appendix.

Section 3

SIMPLE MACHINES AND ENERGY TRANSFER

When you think of machines, do you think of complex equipment like those shown in the photograph? These are most definitely machines, but there are much simpler ones. You use them pretty much every day. If you exclude your personal machine—your body—you still have simple machines all around you. Did you turn a doorknob today? Have you ever shovelled snow? cut some paper? driven a nail or pulled one out? These activities involve the use of simple machines. You use them without even noticing them. In this section you will be learning about these simple machines. You will also see how they can be put together to make much more complicated ways to transfer energy.

Turn to pages 128 and 129 of the textbook. Read the introductory paragraph of "Chapter 7: Simple Machines and Energy Transfer." Check out "What You Will Learn," "Why It Is Important," and "Skills You Will Use." These will give you a quick overview of what you will cover in this section.

Lesson 1

All Kinds of Energy

There's something about the weekend that gives most people a lot of energy. For most, it's a time to unwind and not think about school or work. It's enough to make a person jump up and down. The person in the photo on the left got help by jumping downward off a railing. The person in the photo on the right is getting help from a trampoline. Both of these individuals converted energy in their body into a different form by jumping. In this lesson you will examine the many forms energy can take.

Starting Point
Activity

Keeping Things in Balance

If you have access to a supervised lab, do **Part A**. If you do not have access to a supervised lab, do **Part B**.

Part A

Read the entire activity on page 129 of the textbook. Follow the procedure to complete this activity. **Note:** Save your results for use in Lesson 2 of this section.

1. Record your observations in a table like the following. Complete the Mass x Distance column in the Right Side table.

LEFT SIDE: MASS x DISTANCE		
Hanging Mass (g)	Distance from Centre (cm)	Mass x Distance (g•cm)
50	40	2000

RIGHT SIDE: MASS x DISTANCE		
Counterweight (g)	Distance from Centre (cm)	Mass x Distance (g•cm)
50		
100		
200		
500		

2. What conclusion can you make about the product of the mass of the counterweight and the distance it is hung from the centre of the metre-stick?

Check your answers on page 137 of the Appendix.

Part B

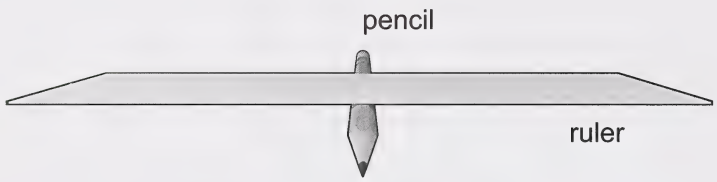
The following activity is similar to the activity in Part A. This activity, however, uses materials and apparatus that are available at home.

Problem: Investigate factors that balance or bring a teeter-totter into equilibrium.

Materials and Apparatus:

- 30-cm ruler
- pencil
- 5 pennies (Pennies should be close to the same year.)

Diagram:



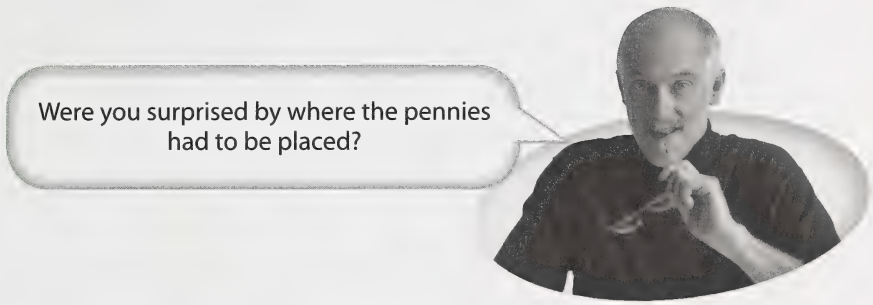
Procedure: Find a flat surface to carry out the activity; then follow these steps:

step 1: Place the pencil on the surface and balance the ruler on the pencil. (Neither end of the ruler should touch the surface.) If your pencil is round, use a mouse pad or book to keep it from rolling. The ruler should sit on the pencil close to the 15-cm mark.

step 2: Place one penny at the 0-cm (or 0.5-cm) mark on the ruler. Place another penny at the 30-cm (or 29.5-cm) mark. Move the second penny until the ruler balances. Where is this second penny on the ruler?

step 3: Remove both pennies and rebalance the ruler. Now stack two pennies at the 22-cm mark on the ruler. Place another penny at about the 1-cm mark. Move this third penny until the ruler balances. Where is this third penny on the ruler?

step 4: Remove all three pennies and rebalance the ruler. Stack four pennies at the 18-cm mark on the ruler. Place a fifth penny at the 1-cm mark. Move this fifth penny until the ruler balances. Where is the fifth penny on the ruler?



The following diagrams and chart summarize the results that a couple of students obtained when doing this activity. (**Note:** If you put your penny 0.5 cm from each end of the first part, your distances would be 14.5 cm from the pencil.)

Diagram A

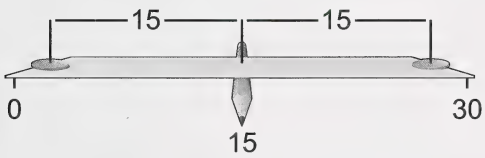


Diagram B

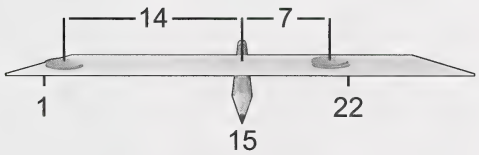


Diagram C

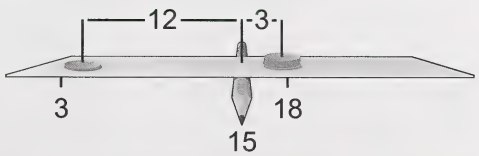


Diagram	Distance Single Penny Is from Pencil (cm)	Number of Pennies on Right Side	Distance Pennies on Right Side Are from Pencil (cm)
A	15	1	15
B	14	2	7
C	12	4	3

3. Find a relationship between the numbers in each row. **Note:** Save your results for use in Lesson 2 of this section.

Check your answer on page 137 of the Appendix.

Turn to page 130 of the textbook. Read the introduction to "All Kinds of Energy." Pay particular attention to the pictures and their captions.

4. Answer "Reading Check" on page 130 of the textbook.

Check your answer on page 137 of the Appendix.

Find Out
Activity

Wheelchair Ramps, Switchbacks, Propellers, and Screws

Read through the entire activity on page 131 of the textbook.

If you have access to a supervised lab, do **Part A**. If you do not have access to a supervised lab, do **Part B**.

Part A

Obtain the required materials and apparatus. Then follow the instructions in "What to Do" to complete the activity.

5. Record your observations in a chart like the following.

Situation	Force (N)	Height (cm)	Distance Moved (cm)
lifted block up onto three books			
slid block up inclined board onto three books			
lifted block up onto six books			
slid block up inclined board onto six books			

6. Answer questions 1 to 4 of "What Did You Find Out."

Check your answers on page 138 of the Appendix.

Part B

A student carried out this experiment. The following information was recorded. Use this information to answer question 6 in Part A.

Situation	Force (N)	Height (cm)	Distance Moved (cm)
lifted block up onto three books	4.0	6	6
slid block up inclined board onto three books	1.5	6	100
lifted block up onto six books	4.0	12	12
slid block up inclined board onto six books	2.5	12	100

Turn to page 132 of the textbook. Read the section titled "What Is Work?"

7. How is a force defined in science?
8. What has to be done to an object for the process to be called work?
9. Write the formula for work.
10. What is a newton-metre of work?
11. What is a joule?

Check your answers on page 138 of the Appendix.

Calculating the amount of work done in a situation is a simple process—at least if the force and distance are known. The following process works well in calculating work.

step 1: Identify the values for force and distance.

step 2: Write the work formula, $W = F \times d$.

step 3: Substitute the values into the work formula.

step 4: Calculate the result.

step 5: Report the result with a good summary sentence.

Example

Find the amount of work done in each of the following situations.

a. A force of 10 N is used to move a stack of paper from the floor to a table that is 1.5 m high.

b. A force of 750 N is used to push a set of bleachers. The bleachers are moved 100 m from the storage area to the edge of the playing field.

Solution

a. **step 1:** Identify the values for force and distance.

The force, F, is 10 N. The distance, d, is 1.5 m.

step 2: Write the work formula.

$W = F \times d$

step 3: Substitute the values into the work formula.

$W = F \times d$
$W = 10\ \text{N} \times 1.5\ \text{m}$

step 4: Calculate the result.

$W = F \times d$
$W = 10\ N \times 1.5\ m$
$W = 15\ N \cdot m$ or $15\ J$

step 5: Report the result with a good summary sentence.

Moving the stack of paper required 15 J of work.

b. The force, *F*, is 750 N. The distance, *d*, is 100 m. (step 1)

$W = F \times d$ (step 2)
$W = 750\ N \times 100\ m$ (step 3)
$W = 75\ 000\ N \cdot m$ or $75\ 000\ J$ (step 4)

Pushing the bleachers required 75 000 J of work. (step 5)

Now, return to Part B of "Find Out Activity: Wheelchair Ramps, Switchbacks, Propellers, and Screws." Use this work formula to calculate the amount of work done. If you did Part A in this activity, use the results from Part B to answer the next two questions.

12. Add a column with the heading "Work (J)" to the table given in Part B. Calculate the amount of work for each situation using the work formula, $W = F \times d$. **Note:** Remember to change centimetres to metres for distance moved when calculating work.

13. a. Which takes more work, lifting the block onto the three books or sliding the block up the incline onto the three books?

    b. Which takes more force, lifting the block onto the three books or sliding the block up the incline onto three books?

    c. Are the results the same for the situation involving the six books?

Check your answers on page 139 of the Appendix.

You can also use the work formula to determine the force required to move an object over a given distance. Substitute the values into the work formula. Then solve for the force, *F*. Refer to the following example.

Example

Pushing a trunk 20 m along a basement floor requires 10 000 J of work. How much force is used to move the trunk?

Solution

Remember: 10 000 J = 10 000 N•m

The distance, *d*, is 20 m. The work, *W*, is 10 000 N•m. Write down the important values.

$$\text{Work} = \text{Force} \times \text{Distance}$$ Write down the formula.

$$W = F \times d$$

$$10\,000 \text{ N•m} = F \times (20 \text{ m})$$ Substitute the values.

$$\frac{10\,000 \text{ N•m}}{20 \text{ m}} = \frac{F \times (20 \text{ m})}{20 \text{ m}}$$ Calculate the result.

$$500 \text{ N} = F$$

$$F = 500 \text{ N}$$

A force of 500 N is used to move the trunk. Report using a summary sentence.

14. a. Define a joule and a newton-metre. How is a joule related to a newton-metre?

    b. How much work is done if you lift a 50-N weight 2 m?

    c. How much work is done if you apply 75 N of force to push a block up a 4-m ramp?

    d. How much work is done if you apply a 5-N force to push a block down a 4-m ramp?

    e. If 500 N•m of work is done lifting a sack of seed grain 2 m, what force is used to lift the grain?

Check your answers on pages 139 and 140 of the Appendix.

Continue by reading "Ramps Are Everywhere" and "You Know You Are Working When . . . " on pages 132 and 133 of the textbook. Read the captions below the illustrations of the cyclists carefully. Answer the following questions.

15. Name four items that use an inclined plane.

16. What is an inclined plane?

17. What two things are required for work to be done in the scientific definition?

18. Why is work not being done by the cyclist in Figure 7.10 on page 133?

19. Why is work done by the cyclist in Figure 7.11 on page 133?

Check your answers on page 140 of the Appendix.

Actually, there is work being done by something in both cases. It is just that the cyclist isn't doing work when the bicycle is coasting downhill.

Notice the two criteria for work to be done. None of the examples say that your body isn't working because it is. They all say that if the object doesn't move because of a force, no work has been done on the object. On a personal level, your body has been doing work. Your heart rate increases and so does your blood pressure. Your blood is moving faster. That is additional work, but it is internal to you. The same is true when you study for an exam. Your brain requires more energy when it is working hard. Your heart rate and breathing rate will increase. This means faster blood flow. You are indeed working harder when you study than when you just sit and stare into space.

20. Answer questions 1 to 4 of "Check Your Understanding" on page 133 of the textbook. For question 1, your reasons are very important.

Check your answers on pages 140 and 141 of the Appendix.

Go to pages 7 and 8 of Assignment Booklet 2B and answer questions 1 to 7.

Lesson 2

Just Prying into Things

In the complex modern world, you can find a lot of simple things that make life easier. What could be simpler than using a hammer and a couple of nails to hold two boards together? Or a mallet to pound the dents out of a car's fender? You find these simple tools used in all kinds of jobs. The tools that are shown are from a class of simple tools called levers. In this lesson you will learn about the different types and uses of levers.

Insert the *Science.Connect 1 Student Multimedia* CD into your computer. Launch the applet *Levers_Intro* from the Levers1 folder. This multimedia segment will give you a good introduction to the parts of a lever and the different classes of levers.

Now, turn to page 134 of the textbook. Read the introductory paragraphs of "Just Prying into Things." You will identify the important parts of a **lever**. You will also learn how the **load distance**, **load**, and **fulcrum** are related and how the **effort distance**, **effort**, and fulcrum are related.

1. Define the following terms:

   - *fulcrum*
   - *effort*
   - *effort distance*
   - *load*
   - *load distance*

2. In Figure 7.12, which letter represents the load distance?

Check your answers on page 141 of the Appendix.

Continue your reading on levers. Read "First Class Levers" on page 134 of the textbook. Then read "First Class Levers Around the House" on page 136. Notice how the fulcrum, effort, and load are placed with a **first class lever**.

3. In a first class lever, how are the fulcrum, effort, and load located?

4. Give three examples of first class levers.

Check your answers on page 141 of the Appendix.

In the Starting Point Activity at the beginning of Lesson 1, you balanced weights at different distances from the centre of a metre-stick or ruler. You found that the product of the mass and the distance from the centre is the same on each side of centre. In the next investigation you will apply this to a first class lever.

Investigation

7-A: A First Class Look Back

If you have access to a supervised lab and you did Part A of "Starting Point Activity: Keeping Things in Balance," do **Part A** of this investigation. If you do not have access to a supervised lab and you did Part B of "Starting Point Activity: Keeping Things in Balance," do **Part B** of this investigation.

Part A

Turn to page 135 of the textbook and read the entire investigation.

Follow the steps in "What to Do" carefully to complete this investigation.

5. How much is each of the following masses raised when the 50-g mass on the left is lowered by 10 cm?

   a. 50-g mass placed on the right side 40 cm from the centre

   b. 100-g mass placed on the right side 20 cm from the centre

   c. 200-g mass placed on the right side 10 cm from the centre

6. The product of the mass and the distance the mass on the left is lowered is 10 x 50, or 500. What is the product of the mass and the distance the mass on the right is raised in each part in question 5?

   a. The 50-g mass on the right is raised 10 cm.

   b. The 100-g mass on the right is raised 5 cm.

   c. The 200-g mass on the right is raised 2.5 cm.

7. How does the product on the left compare with the product on the right?

8. You can call the distance the weight on the left moves the effort distance and the distance the weight moves on the right the load distance. How does the effort distance compare to the load distance when a larger mass is moved?

Check your answers on page 142 of the Appendix.

Part B

Here are the diagrams and the chart from Part B of "Starting Point Activity: Keeping Things in Balance." If you look at the way the activity was set up, you should recognize a first class lever.

Diagram A

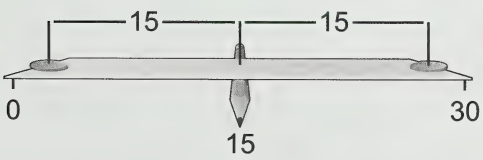


Diagram B

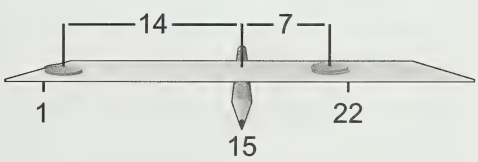


Diagram C

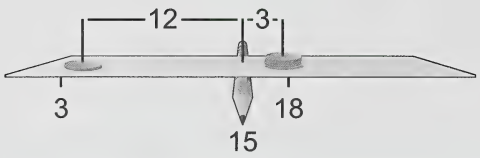


Diagram	Distance Single Penny Is from Pencil (cm)	Number of Pennies on Right Side	Distance Pennies on Right Side Are from Pencil (cm)
A	15	1	15
B	14	2	7
C	12	4	3

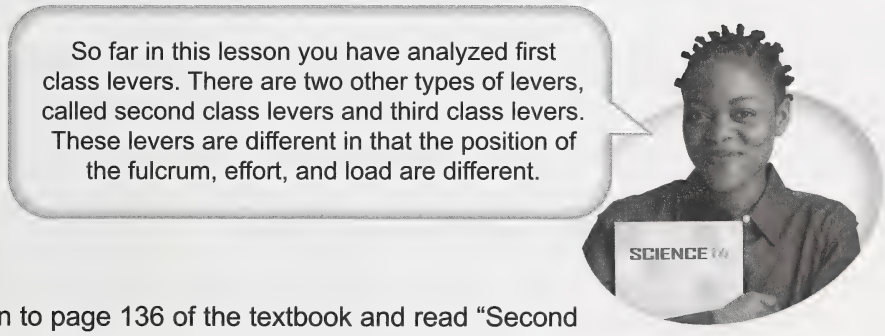
Recall, from Section 2: Lesson 1 that a penny has a mass of about 2.35 g. Pretend that the single penny is the effort and the other pennies are the load. The preceding table could be rewritten to give the following chart.

Effort		Diagram and Calculations	Load	
Mass (g)	Distance (cm)		Mass (g)	Distance (cm)
2.35	15	Diagram A: Effort = 2.35 x 15 = 35.25 Load = 2.35 x 15 = 35.25	2.35	15
2.35	14	Diagram B: Effort = 2.35 x 14 = 32.90 Load = 4.70 x 7 = 32.90	2 x 2.35 = 4.70	7
2.35	12	Diagram C: Effort = 2.35 x 12 = 28.20 Load = 9.40 x 3 = 28.20	4 x 2.35 = 9.40	3

9. What do the calculations show you about effort and distance from the centre and load and distance from the centre?

Check your answer on page 142 of the Appendix.

A first class lever lets you move large objects with small amounts of effort. In "Starting Point Activity: Keeping Things in Balance," you saw that one penny could balance four pennies. But the four pennies were closer to the pencil than the single penny. In fact, the single penny was 4 times further away from the pencil. Another way to say it is, in a first-class lever, a small load on one side can balance a larger load on the other side if the larger load is closer to the fulcrum than the small load.


So far in this lesson you have analyzed first class levers. There are two other types of levers, called second class levers and third class levers. These levers are different in that the position of the fulcrum, effort, and load are different.
SCIENCE

Turn to page 136 of the textbook and read "Second Class Levers." Check out the diagram to see how the fulcrum, effort, and load are related in a second class lever. Then study the information in "Third Class Levers" on page 137. Use the diagram to compare how second and third class levers are different. They are similar in that the effort and load both move in the same direction.

10. Where are the fulcrum, effort, and load located in a second class lever?

11. List three examples of second class levers.

12. Where are the fulcrum, effort, and load located in a third class lever?

13. List three examples of third class levers.

14. How is a third class lever different from a second class lever?

15. a. Draw and label the parts of a first class lever.

    b. Draw and label the parts of a second class lever.

    c. Draw and label the parts of a third class lever.

Check your answers on pages 142 and 143 of the Appendix.

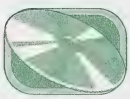
Turn to page 138 of the textbook and read "Your Body Has Levers Too." Notice that, throughout this lesson, careful attention has been given to the class of lever being discussed. You will find that a body part, like the arm, can be more than one class of lever.

16. Which muscle is used when your arm is used as a first class lever?

17. Which muscle is used when your arm is used as a third class lever?

18. Explain how the arm is used differently as a first class lever compared to being used as a third class lever.

Check your answers on page 143 of the Appendix.



Insert the *Science 14 Multimedia* CD into your computer. View the segment "Levers." It will provide you with a good review of the three classes of levers. It will also provide you with an introduction to the idea of distance, force, and speed multipliers.

Now, turn to page 138 of the textbook and read the section "Distance Multipliers." In the reading, you will see that this can be used as a speed multiplier as well. Take note as to which class of lever is commonly used as a speed multiplier. Once you have covered distance multipliers, read "Force Multipliers" on page 139. In a force multiplier, the lever is used to put a large force on the load using a small effort.

19. Which class of lever is used as distance and speed multipliers?

20. Give two examples of distance and speed multipliers.

21. Which class or classes of levers are commonly used as force multipliers?

22. How does the effort distance compare with the load distance when a lever is used as a force multiplier?

23. What are three differences between a distance multiplier and a force multiplier?

CHECK Check your answers on page 144 of the Appendix.

Insert the *Science.Connect 1 Student Multimedia* CD into your computer. Open the applet *Levers_FDM* from the Levers2 folder. This applet covers force and distance multipliers. You should find this to be a good summary of the material in this lesson.

24. Answer questions 1 to 6 of "Check Your Understanding" on page 139 of the textbook.

CHECK Check your answers on pages 144 to 148 of the Appendix.

Go to ... Go to pages 9 and 10 of Assignment Booklet 2B and answer questions 8 to 17.

Lesson 3

Wheels, Pulleys, and Blocks

When you think of lifting a heavy object onto a ship or at a construction site, you likely think of a crane. When you look at a crane, you see steel ropes and pulleys. Large cranes have lifting capacities over 500 tons. How do they manage to lift all that material? In this lesson you will learn about pulleys, wheels, and blocks.

Turn to page 140 of the textbook. Read the introduction to "Wheels, Pulleys, and Blocks." You will see that the descriptions use terms from the previous lesson, like *effort*, *load*, and *equilibrium*.

1. What is a pulley?

2. When is a pulley a simple machine?

3. When is a pulley in equilibrium?

CHECK Check your answers on page 149 of the Appendix.

Investigation

7-B: Pulleys Make Work Easier—Sometimes

Read through the investigation on pages 140 and 141 of the textbook.

If you have access to a supervised lab, do **Part A**. If you do not have access to a supervised lab, do **Part B**.

Part A

Carefully follow the procedure, and complete the investigation.

4. Copy and complete a chart like the following.

Part	Load (N)	Load Distance (N)	Work Done Without Pulley (J)	Using Pulley		
				Effort Required (N)	Effort Distance Required (m)	Work Done (J)
1						
2						
3						

5. Answer questions 1, 2, and 3 of "Analyze" on page 141.

6. How does the amount of work done in lifting the block compare in each of the three pulley systems?

7. Is it reasonable that the amount of work done is the same for each set of pulleys? Why?

Check your answers on page 149 of the Appendix.

Part B

The following table contains the results one student obtained from the investigation.

Part	Load (N)	Effort Required to Lift Load (N)	Effort Distance Required to Lift Load (m)
1	4	4.1	0.1
2	4	2.1	0.2
3	4	1.4	0.3

8. Answer questions 1, 2, and 3 of "Analyze" on page 141.

9. Determine the work done in each part. Compare the amount of work done with each pulley system. (**Remember:** Work = Force x Distance)

10. Is it reasonable that the amount of work done is approximately the same for each pulley system? Why.

Check your answers on pages 149 and 150 of the Appendix.

Turn to page 142 of the textbook. Read the part titled "Fixed and Moveable Pulleys."

11. What is the difference between a fixed pulley and a moveable pulley?

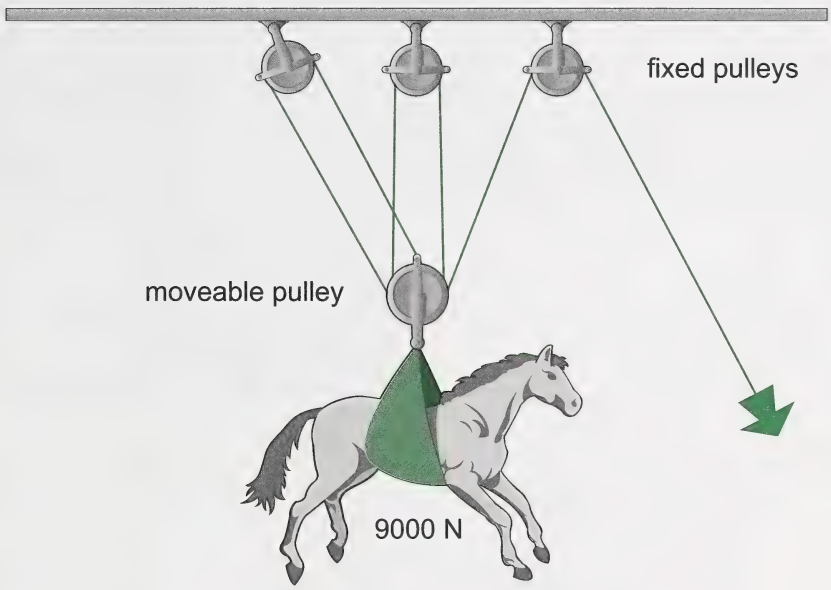
12. How is a fixed-pulley system similar to a teeter-totter?

Check your answers on page 150 of the Appendix.

In Investigation 7-B you used different numbers of pulleys to lift a block. You found that only the direction of the effort was changed when one fixed pulley was used. When more than one pulley was used, the effort was reduced but the distance you had to pull the cord increased. Actually, the effort required is divided by the number of ropes or cords that are lifting the load. Also, the distance the effort is moved is multiplied by the number of cords that are lifting the load. Study the following example closely. Take note that the cord that is pulled (the cord between the last pulley and the effort) is not counted.

Example

A horse weighs 9000 N. It is placed in a harness. The harness is attached to a set of pulleys (as shown in the diagram).



a. How far would you have to pull the rope to lift the horse 1 m?

b. How much force would you have to apply to lift the horse?

Solution

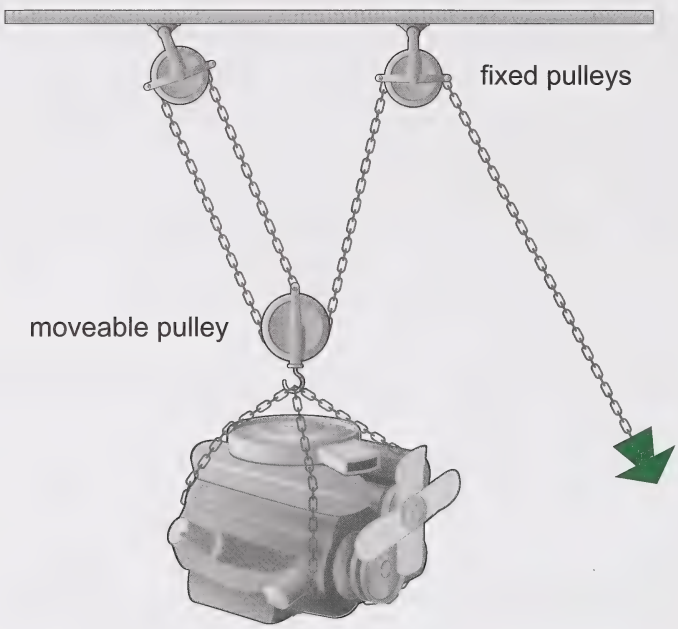
a. To lift the horse 1 m, you would have to shorten 5 rope segments 1 m each. That would require you to pull in 5 m of rope.

b. The arrangement of pulleys is a force multiplier. For every 1 N of force you apply to the rope, 5 N is applied to the load. Therefore, you would need to apply 9000 ÷ 5 = 1800 N of force to lift the horse.

A pulley system, such as the one in the preceding example, is called a block and tackle. You can learn more about a block and tackle at the following Internet site:

http://www.howstuffworks.com/pulley.htm

13. A pulley system, such as the one shown, is used to lift a motor that weighs 5400 N.



a. How much force is required to raise the motor?

b. How far do you need to pull the chain to raise the motor 1.5 m?

c. How far will the motor rise if you pull the chain 6 m?

Check your answers on page 150 of the Appendix.

Insert the *Science 14 Multimedia* CD into your computer. View the segment "Pulley Power." It provides you with a good review of fixed and moveable pulleys. After, view the segment "Two-Pulley Systems." It provides more information and examples.

Continue on page 142 of the textbook by checking out the "Career Connect." Is this a career that you may become interested in?

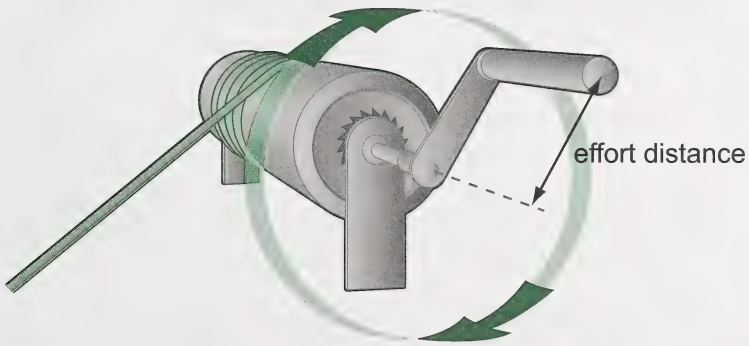
Now, turn to page 143 of the textbook and read "Turning and Turning: The Wheel and Axle." The wheel and axle is a simple machine involving wheels. Notice that the simple machines here have one common feature: in each case, they increase the force on the load by increasing the distance the effort moves through. For example, the wheel is larger than the axle, the handle on the winch turns through a larger circle than the roller, and the handle on the wrench makes a larger circle (wheel) than the nut it is turning.

14. What is a wheel and axle?

15. Give three examples of a wheel and axle.

16. What is the effort distance on a wrench?

17. In a winch, the effort distance is the distance from the centre of the drum to the centre of the handle. What is the load distance of a winch?



Check your answers on pages 150 and 151 of the Appendix.

Find Out
Activity

The Great Pyramids of Egypt

Read through the activity on page 144 of the textbook.

Use either the "Internet Connect" or your local library to research information on the simple machines the Egyptians could have used.

18. Answer question 1 of "What to Do."

19. Answer question 2 of "What Did You Find Out?"

CHECK Check your answers on page 151 of the Appendix.

If possible, and if you are interested, check out the following Internet site. It is a site run by the Egyptian government that provides information about the design and construction of the pyramids.

http://www.touregypt.net/construction/index.htm

Now that you have examined more information about the building of the pyramids, how were your predictions on the machines used?

20. Answer questions 1 to 5 of "Check Your Understanding" on page 144 of the textbook.

CHECK Check your answers on pages 151 and 152 of the Appendix.

Go to ... Go to pages 11 to 13 of Assignment Booklet 2B and answer questions 18 to 24.

Lesson 4

Spinning Our Wheels: Energy and Efficiency

Each of these people is more efficient than they could have been thirty years ago. Back then, cell phones weren't around. To contact someone, you had to be wherever there was a telephone. Today, you can be in contact with people wherever you are (or at least wherever there is service). Think how much extra effort a farmer out in the middle of a field would have to expend to get to a telephone. Now, it's just a reach away. In this lesson you are going to learn about efficiency as it relates to machines and energy.

Turn to page 145 of the textbook and read the introductory paragraphs of "Spinning Our Wheels: Energy and Efficiency. You will learn that energy gets "wasted" when a machine is used. However, you often find it necessary to use a machine that wastes energy as opposed to not getting a job done.

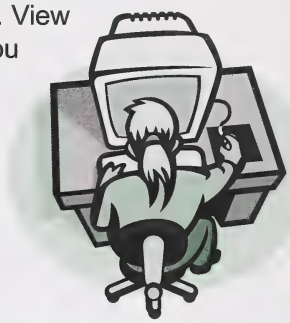
1. What are three ways through which a machine will lose energy?

2. In "Find Out Activity: Wheelchair Ramps, Switchbacks, Propellers, and Screws" in Lesson 1, you found that it took more work to move the block up the incline onto the books than it did to lift the block onto the books. Where was the energy lost?

3. Suppose you had to move a 500-kg block. Why would you use an incline to move the block if it takes more work than lifting it directly?

Check your answers on page 152 of the Appendix.

Insert the *Science 14 Multimedia* CD into your computer. View the segment "Friction: There's the Rub." It will provide you with a good overview of friction. You will see several places where friction is useful to you.



4. When is friction useful?

5. When is friction not useful?

Check your answers on page 153 of the Appendix.

Continue on page 145 of the textbook and read "Efficiency." You will find that the efficiency of a machine is a comparison. It compares the useful work done against the energy used to do the work. Often, it is expressed as a percentage or a ratio.

6. What is efficiency of a machine?

7. Why are machines never 100% efficient?

Check your answers on page 153 of the Appendix.

Return to the *Science 14 Multimedia* CD and view the segment "Reducing Friction." It will provide you with an overview of reducing friction. You will see several ways to reduce friction. Lubricating is one way to improve the efficiency of simple machines.

8. How can friction be reduced?

9. What is the effect of a lubricant on the efficiency of a machine?

Check your answers on page 153 of the Appendix.

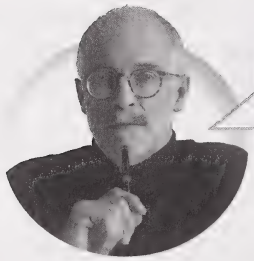
Now, turn to page 146 of the textbook and read "Efficiency Around the House." You will become more aware of why closing doors and turning off lights is useful. Whoever pays the energy bills in your home will be grateful too.

10. Which type of technology listed in Table 7.1 is the most efficient? Which is the least efficient?

11. What does the EnerGuide Number indicate?

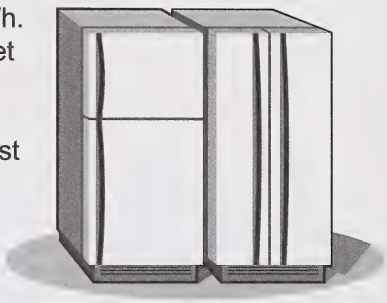
12. Answer "Reading Check" on page 146 of the textbook.

Check your answers on page 153 of the Appendix.



Study the following example to understand how the EnerGuide Number can be used to your advantage when shopping.

Example



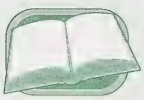
You need a refrigerator. Electricity costs $0.12/kWh. There are two models of refrigerators that will meet your needs. Model A costs $750. Model B costs $800, but it has an EnerGuide Number that is 200 less than model A's. Which one would be more cost effective over a 10-year period?

Solution

The extra electricity cost for model A is $0.12 x 200 = $24 each year. In 10 years, this would be $24 x 10 = $240. This is more than enough to recover the initial $50 difference. Therefore, model B is the more cost-effective purchase.

Investigation

7-C: Energy Efficiency in the Home

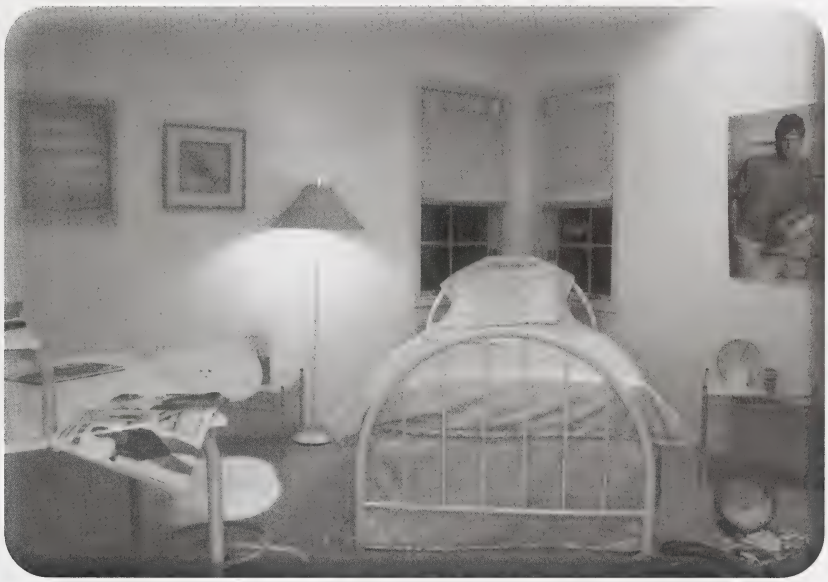


Turn to page 147 of the textbook. Read through the entire investigation. Pay particular attention to the graph at the bottom of the page.

13. Answer questions 1 and 2 of "Analyze." For question 2, you can discuss the ways of reducing electricity with family or friends.

Check your answers on pages 153 and 154 of the Appendix.

An understanding of how electricity costs are determined is important in helping you realize how to become more energy efficient at home. A kilowatt-hour is a measure of the amount of energy an electrical item will use. One kilowatt-hour is 1000 watts of energy used in 1 hour. The number of watts each electrical item uses per hour varies. A 100-watt light bulb will use 100 watts in 1 hour. A 60-watt light bulb will use 60 watts in 1 hour.



14. Your bedroom may have a light fixture on the ceiling or wall with a 60-watt bulb.

    a. If for one year you leave that light on for 1 h per day when you are not in the room, how many kilowatt-hours of energy have you wasted?

    b. If the cost of electricity is $0.12/kWh, what is the cost of the wasted energy?

    c. Is this a significant cost?

15. Many electric utilities want you to change from incandescent light bulbs to fluorescent lighting. They suggest that fluorescent lighting uses only a quarter of the power for the same amount of light. Why would an electric utility suggest using less power?

Check your answers on pages 154 and 155 of the Appendix.

Turn to pages 148 and 149 of the textbook and read "The Bigger Problem." This section asks you to consider energy-saving ideas. Read the captions of the pictures closely to see why the pictures show energy-saving ideas.

16. What are two benefits to using less energy?

17. What are two environmental concerns related to the use of fossil fuels?

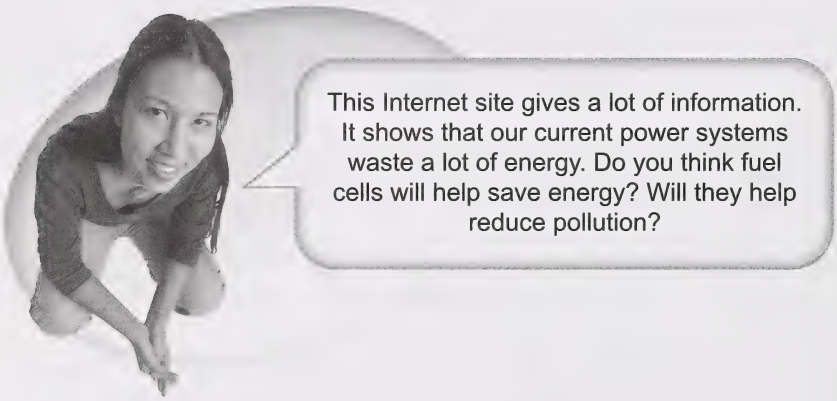
18. What are two sources of energy that are not obtained from fossil fuels?

19. What is a Ballard fuel cell?

Check your answers on page 155 of the Appendix.

In the information given in Figure 7.28, you read about Ballard fuel cells. You can find more information about fuel cells at the following website:

http://science.howstuffworks.com/fuel-cell.htm


This Internet site gives a lot of information. It shows that our current power systems waste a lot of energy. Do you think fuel cells will help save energy? Will they help reduce pollution?

20. Turn to page 149 of the textbook and answer questions 1 to 4 of "Check Your Understanding."

Check your answers on pages 155 and 156 of the Appendix.

Go to pages 13 and 14 of Assignment Booklet 2B and answer questions 25 to 29.

Section 3 Review

In this section you studied simple machines and energy. You looked closely at three simple machines: levers, wheels and axles, and pulleys. You learned how work is defined. You saw how simple machines can make jobs easier. They can allow you to exchange effort for distance (or speed). They also can let you exchange distance for effort. You also analyzed how machines are inefficient. They always use more energy to complete a task than if the energy could be applied directly. To save our resources, people need to try to overcome this inefficiency. Also, the increasing costs of energy provide another good incentive to become more energy efficient.

If you play hockey or have watched a player shoot the puck, you witnessed a third class lever in action. If you have used a lever to pry a large stone out of the ground, you have seen a first class lever in action. Simple machines are used around you every day.

You have now completed all of the concepts for this section. To review what you have studied, do the following questions. If necessary, go back and read over parts of this section while you answer the questions.

1. Complete the following word search. It involves important terms from this section.

AXLE
EFFICIENCY
EFFORT
ENERGY
EQUILIBRIUM
FIXED
FULCRUM
INCLINED PLANE
JOULE
KILOWATT-HOUR
LEVER
LOAD
MOVEABLE
MULTIPLIER
NEWTON-METRE
PULLEY
SIMPLE MACHINE
THERMAL ENERGY
WHEEL
WORK

E	K	K	F	O	T	P	E	Y	V	A	S	Z	R	Z
F	N	S	I	M	U	L	T	I	P	L	I	E	R	H
F	Y	A	E	L	C	B	S	X	R	E	M	M	G	F
I	Q	G	L	Q	O	Q	W	S	L	J	P	H	I	W
C	E	E	R	P	U	W	G	B	O	Y	L	X	V	A
I	Y	E	D	E	D	I	A	U	A	B	E	I	P	F
E	F	J	J	F	N	E	L	T	D	D	M	P	F	Q
N	V	J	S	F	V	E	N	I	T	B	A	V	U	A
C	Z	T	U	O	I	M	L	I	B	–	C	C	L	L
Y	T	U	M	R	V	R	Z	A	L	R	H	C	C	C
T	E	E	E	T	B	L	M	X	M	C	I	O	R	W
H	A	V	T	Q	R	Q	E	L	T	R	N	U	U	O
N	E	W	T	O	N	–	M	E	T	R	E	I	M	R
L	O	X	N	H	H	R	I	E	H	M	Z	H	Y	K
P	O	J	C	A	H	L	H	Z	U	W	E	K	T	E

2. Answer the following "Chapter 7 Review" questions on pages 150 and 151 of the textbook.

   a. question 1 of "Reviewing Key Terms"

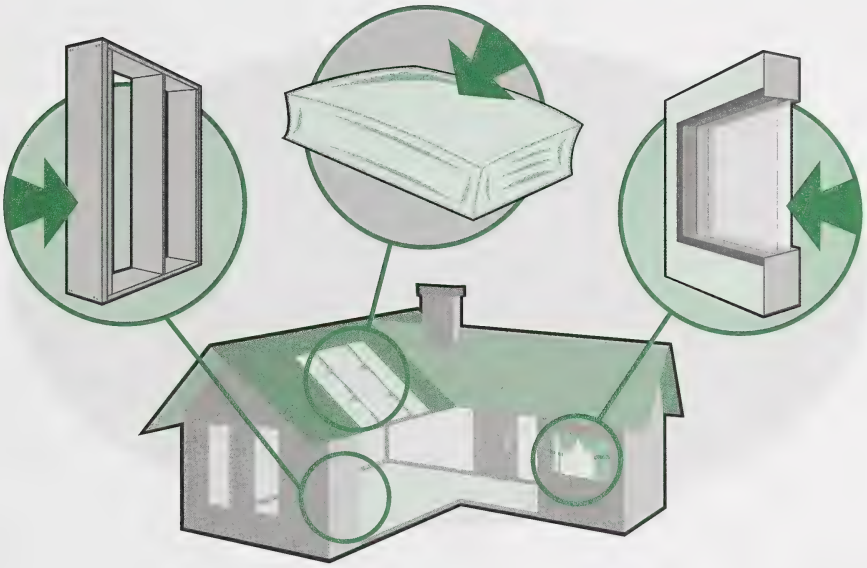
   b. questions 3 and 5 of "Understanding Key Ideas"

   c. question 7.a. of "Problem Solving/Applying"

   d. question 10 of "Critical Thinking"

Check your answers on pages 156 and 157 of the Appendix.

Module Summary



In this module you learned a lot about heat and energy. You saw how the modern molecular theory of matter and an understanding of heat developed. You found that heat transfers in three main ways: conduction, convection, and radiation. You studied how controlling heat transfer involved trying to prevent these transfer mechanisms. You then learned about work and its relationship to energy. You studied simple machines and discovered how you can trade distance for effort. You also examined the inefficiencies that machines introduce.

Heat transfer has a lot of applications that you use each day. Modern houses are constructed with thick walls and up to 50 cm of insulation in the ceiling. Windows are triple-glazed and contain a mixture of argon gas between the panes. This is done to reduce the amount of heat transferred from inside the house to the outdoors on cold winter days. Do you know someone who is building a new home and is using some of the technologies that reduce heat transfer?

APPENDIX

GLOSSARY ■ SUGGESTED ANSWERS ■ IMAGE CREDITS

Glossary

Brownian motion: the jiggling motion of particles

conduction: a method of heat transfer that requires contact

convection: a method of heat transfer that involves currents

distance multiplier: a simple machine that moves the load through a long distance by moving the effort through a short distance

efficiency: a comparison of the work done to the work expended to do the work

This is usually as a percentage.

effort: the force needed to move an object

effort distance: the distance between the fulcrum and the effort

energy: the ability to do work

equilibrium: balance

first class lever: a lever with the fulcrum between the effort and load

fixed pulley: a pulley that does not move

It does not change the effort required.

force: a push or a pull

force multiplier: a simple machine that exerts a large force on the load when a small effort is applied to the machine

friction: resistance to motion of two objects pressed together

fulcrum: the support point of a lever

heat: the sum of all kinetic energies of all particles of a substance

heat absorption: the rate at which a substance absorbs heat

hyperthermia: abnormally high body temperature

This occurs when a person's body temperature is more than 4°C above normal.

hypothermia: abnormally low body temperature

This occurs when a person's body temperature is more than 4°C below normal

inclined plane: a simple machine that consists of a sloping surface

insulation: a material that slows heat transfer

joule: the unit used to report work (1 J = 1 N•m)

kilowatt hour: the amount of electricity consumed when a 1000 watts of power is used for 1 h

kinetic energy: a form of energy associated with motion

land breeze: a mild wind that blows from cool land out to a warmer sea

load: the object moved by a lever

load distance: the distance between the fulcrum and the load

moderate: the effect of large bodies of water storing large amounts of thermal energy on the adjacent land

moveable pulley: a pulley that moves with the load

It changes the effort required.

newton-metre (N•m): the work done when 1 N of force is used for a distance of 1 m

pulley: a simple machine made of a grooved wheel over which a rope is looped

radiation: a method of heat transfer that involves electromagnetic waves

R-value: a measure of how well insulation slows heat transfer

sea breeze: the cool wind that blows from a cool sea or lake toward the warmer land

second class lever: a lever with the load between the fulcrum and the effort

simple machine: a tool or machine that involves only one movement

specific heat capacity: the measure of a substance's ability to absorb or lose heat

This is measured in J/(g•°C)

temperature: the average kinetic energy of all particles in an object

thermal energy: the sum of all kinetic energies of all particles of a substance; heat

third class lever: a lever with the effort between the fulcrum and the load

wheel and axle: a simple machine consisting of a wheel turning a smaller rod

work: what is done when a force moves an object

vacuum bottle: a container that slows all three methods of heat transfer

Suggested Answers

Section 1: Lesson 1

1. Answers may vary. A sample lab report is given.

Title: Watching Colour Spread in Water

Problem: Is something moving in water when water is sitting still?

Prediction: Something is moving in water even when water is sitting still.

Materials and Apparatus:

- a drinking glass
- cold water
- hot water
- a watch
- food colouring
- measuring cup

Procedure:

step 1: Put a cup of cold water into the glass. Let it stand for about three minutes.

step 2: Put one drop of food colouring into the water from about 1 cm above the water.

step 3: Observe what happens, and keep track of when it happens.

step 4: Repeat steps 1 to 3 using hot tap water instead of cold water.

Observations:

cold water: The food colouring spread slowly through the water. It broke apart into strands. The strands moved away in random directions. The colour became less intense as it moved away from its original position.

hot water: The food colouring spread through the water, but faster than in the cold water. It broke apart into strands. The strands moved away in random directions. The colour became less intense as it moved away from its original position.

Conclusion: Something is moving in water, even when the water is sitting still. My prediction was correct.

2. **Textbook questions 1, 2, and 3 of "Analyze," p. 85**

    1. The food colouring spreads slowly through the water. It takes time before it breaks apart into strands. The strands move away in random directions. The colour becomes less intense as it moves away from its original position.

    2. Other than the speed, the motion of the food colouring was very similar.

    3. The actions are faster in the hot water.

3. **Textbook questions 4 and 5 of "Conclude and Apply," p. 85**

    4. a. In Module 1, matter was discussed as being made of extremely small particles. The moving water molecules hit food colouring molecules and bounce them around.

    b. Water molecules knock the food colouring around. Eventually, the food colouring molecules were knocked out of the drop by the water molecules.

c. The motion in cold and hot water looked about the same except for the speed in which things happened. Everything happened faster in the hot water. The molecules in the hot water were moving faster, so they moved the food colouring faster.

4. Robert Brown observed that the pollen grains in a drop of water were bounced around even though the microscope was quite still.

5. The zigzag (jiggling) motion became known as Brownian motion.

6. Eventually, Robert Brown proposed that the water must be made up of unseen particles that are in constant motion. These water particles hit the pollen grains, causing the pollen grains to bounce.

7. Brownian motion is the random jiggling motion of particles. If temperature increases, Brownian motion increases. If temperature decreases, Brownian motion decreases.

8. The pollen grain moves in a random, zigzag pattern when suspended in water.

9. The accepted hypothesis is that very small, invisible particles, called molecules, are crashing into the pollen grain, forcing it to move.

10. The reason given as to why this hypothesis is acceptable is that if you increase the temperature of the water, the Brownian motion increases.

11. **Textbook questions 1, 2, and 3 of "Check Your Understanding," p. 85**

    1. Brown guessed that the water molecule was the smallest part of the mixture of water and pollen grains.

    2. The motion of pollen grains in water is named Brownian motion, after Robert Brown. This motion is a random jiggling motion.

    3. The motion of food colouring in the water speeds up as the temperature of the water increases.

12. **Textbook questions 1, 2, and 3 of "What Do You Think?," p. 81**

    1. The heat comes from the rubbing of the bit against the wood. This is called friction.

    2. The wood in the groove will get hot. It might even get hot enough to burn.

    3. The leather would protect their skin in an accident. It would prevent their skin from rubbing against the road.

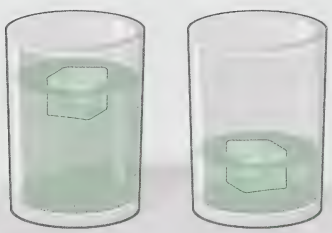
13. Count Rumford's worker discovered that the drill bit used to bore the cannon barrel became extremely hot.

14. Rumford noticed that friction caused the object to become hot. He also noticed that heating an object didn't increase its weight.

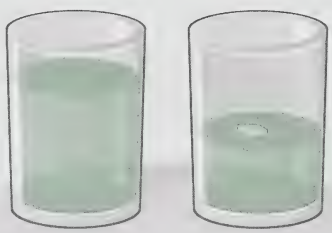
Section 1: Lesson 2

1. Diagrams will vary. Sample diagrams are given.

a.



b.



2. You should have observed that the ice cube in the glass with more water melted faster.

3. The glass with more water had more thermal energy (heat).

4. Robert Brown said thermal energy was related to the jiggling motion of the particles of a substance.

5. Kinetic energy measures the energy of motion of particles.

6. Temperature is defined as the average of all the kinetic energies of all the particles in an object.

7. Thermal energy (heat) is defined as the sum of all kinetic energies of all the particles in an object.

8. An ice cube would melt faster in the beaker on the right. This is because the beaker on the right has more thermal energy (heat) to pass on to the ice cube.

9. **Textbook question "Reading Check," p. 86**

   The average kinetic energies are the same.

10. **Textbook questions 1 and 2 of "Check Your Understanding," p. 87**

    1. Temperature is the average of all kinetic energies of all particles in an object. Heat is the sum of all kinetic energies of all particles in an object. Temperature is the same for any size object under the same conditions. Thermal energy (heat) is dependant on the size of the object. The larger the object, the more thermal energy (heat) it contains.

    2. As the pan gets hotter, there is more kinetic energy in the particles making up the pan.

Section 1: Lesson 3

1. a. Student answers will vary. A sample lab report is given.

    Title: Blending Water

    Problem: What will be the final temperature if you mix equal quantities of water at different temperatures?

    Prediction: The temperature of the water mixture will be halfway between the two starting temperatures.

    Materials and Apparatus:

    - 3 beakers (or glasses)
    - thermometer
    - hot and cold water

    Procedure:

    step 1: Put 100 mL of hot water into a glass.

    step 2: Measure the temperature of the hot water.

    step 3: Put 100 mL of cold water into another glass.

    step 4: Measure the temperature of the cold water.

    step 5: Pour the two water samples together into a larger cup and wait 2 minutes.

    step 6: Record the resulting temperature.

Observations:

Temperature of the hot water: 52°C
Temperature of the cold water: 8°C
Temperature of the mixture: 27°C

Conclusion: Mixing equal quantities of water at different temperatures results in a final temperature that is about halfway between the two starting temperatures.

2. **Textbook questions 1, 2, and 3 of "What Did You Discover?," p. 87**

    1. The final temperature was about halfway between the two starting temperatures.

    2. The final temperature would be the same—about halfway.

    3. The final temperature would be about the average of the two starting temperatures.

3. a. You would know by measuring the temperature of the cooler bar. If it is increasing, that means heat is moving from the heat source (flame) to the cooler bar.

    b. The heat will flow until both objects reach the same temperature (after removing the heat source).

4. Heat is transferred by conduction through the contact between two objects (e.g., pot and burner in Figure 5.10). The faster-moving molecules in the burner collide with the molecules in the pot and pass on kinetic energy to the molecules of the pot.

5. Convection is the movement of heat by a fluid, such as air rising.

6. The two processes involved are conduction and convection.

7. Radiation is the transfer of heat by vibrating electrons, which makes an electromagnetic wave called an infrared wave.

8. Radiation is different from convection in that heat can be transferred to the side or downward by radiation.

9. a. The pot touching the heating element shows heat transfer by conduction.

    b. The water in the pot near the bottom will be heated and rise. Colder water from the sides will move down to take its place. This shows heat transfer by convection.

    c. The hand by the pot is heated without any contact or being above the pot. This shows heat transfer by radiation.

10. **Textbook questions 1 and 2 of "Prediction," p. 90**

    1. Copper will conduct heat the fastest.

    2. The order from fastest rate of heat transfer to the slowest is copper, aluminum, iron, and glass. You may know some cooking pots have copper on the bottom for better heat transfer. Aluminum and iron (steel) have also been used for cooking. Glass normally is not used for cooking pots.

11. **Part 1:** The wax on the metal rod melted more quickly than the wax on the glass rod.

    Part 2: The wax beads melted fastest on the copper rod. The order was copper, aluminum, brass, iron, and glass. **Note:** One of the rods on the heat conductivity apparatus used in Part 2 is brass.

12. a. **Textbook questions 1 and 2 of "Analyze," p. 91**

    1. Metals transfer heat faster than non-metals.

    2. copper, aluminum, brass, iron, and glass

    b. **Textbook questions 3 to 6 of "Conclude and Apply," p. 91**

    3. You may have had differences between your predictions and your results. You may not have realized that aluminum was such a good conductor of heat or you may have thought iron was the best conductor.

    4. Places or items at home where you want a fast transfer of heat are as follows:

        - stoves
        - fireplaces
        - cooking utensils (pots and pans)
        - radiators

        Places or items at home where you want a slow transfer of heat are as follows:

        - freezers
        - refrigerators
        - winter clothing
        - walls of your home

    5. A metal baking pan is best so it transfers heat quickly. A glass baking pan would allow heat to build up in the glass.

    6. Materials that transfer heat quickly will feel cold as the heat from your hand will be transferred away quickly.

13. Answers will vary. A sample answer is given.

    The three containers that were used are

    - container 1: glass
    - container 2: iron (tin can)
    - container 3: Styrofoam™

14. Answers will vary. A sample observation and conclusion are given.

    Observations: The time it took for the ice to melt in the containers are

    - container 1 (glass): 2 min 50 s
    - container 2 (iron): 1 min 45 s
    - container 3 (Styrofoam™): 12 min 35 s

    Conclusion: The iron container was the best conductor. The Styrofoam™ container was the poorest conductor.

15. **Textbook questions 1 to 4 of "Check Your Understanding," p. 91**

    1. a. convection

       b. conduction

       c. radiation

    2. a. Yes, thermal energy flows from the hot object to the cooler object.

       b. The faster-moving molecules of the hot object hit molecules in the cooler object. These cool molecules begin moving faster. This shows heat has been transferred from the hot object to the cooler one.

    3. Radiant heat from the bonfire heats the side facing it. The part facing away doesn't receive this radiant heat. The flames and smoke rise due to convection. The heat of the fire makes the air above it hotter. The molecules spread out and are, thus, less dense. This less dense, warm air rises, carrying the smoke and flame with it.

    4. The metal spoon will seem cooler. The metal conducts heat faster than wood. The heat leaves your hand faster into the metal.

Section 1: Lesson 4

1. Answers will vary. Predictions should be similar to the following:

   It would be best to place the heat ducts near the floor in a basement room because hot air rises.

2. a. **Textbook questions 1 to 5 of "Analyze," p. 93**

   1. The food colouring rises and moves toward the end of the tank with the colder water.

   2. The food colouring sinks to the bottom. It then moves toward the end of the tank with the warmer water.

   3. The smoke is drawn down the cold chimney.

   4. The smoke moves toward the heat source (candle) in the gas convection apparatus.

   5. The smoke rises up the hot chimney.

   b. **Textbook questions 6, 7, and 8 of "Conclude and Apply," p. 93**

   6. The water above the heat source warms up and expands, becoming less dense. The less dense water rises and is replaced by the cooler water from the other end of the pan. This sets up a convection cycle of warm water rising and moving away from the heat source and cooler water sinking and moving toward the heat source.

   7. Air above the heat source (candle) is heated and expands, becoming less dense. It then rises and is replaced by the cooler air from the other end of the apparatus. This draws air down the cold chimney to replace the warm air that rose up the hot chimney.

   8. The best location for heat ducts would be near the floor. If the heat ducts are near the floor, heat from the ducts will heat up objects and people near the floor before it rises.

c. **Textbook questions 9 and 10 of "Extend Your Knowledge," p. 93**

9. Answers will vary. Some situations are as follows:

   - hot-water heating system in a building
   - cooling systems in vehicle radiators
   - boiling water in a pot

10. Answers will vary. Some situations are as follows:

    - forced-air heating in a building
    - heating a room with a wood stove
    - living in a cabin near a lake

3. The potassium permanganate starts to dissolve and rises to the top of the water in the tank. Then it flows away from the heat source along the top of the water.

4. When the water is just heating up, the convection cycle is small and cycles near the heat source. Once the water in the tank has warmed up, the convection cycle is as large as the tank.

5. The major method through which heat is transferred in liquids (fluids) and gases is **convection**.

6. Heat is transferred in solids through **conduction**.

7. Radiation is the form of heat transfer that involves wave-like forms that are transmitted from the heat source.

8. Radiation is transmitted in all directions from a heat source.

9. a. Refer to the answers to question 2.b.

   b. Refer to the answers to question 2.c.

   c. Answers will vary. Your prediction may be similar to the following:

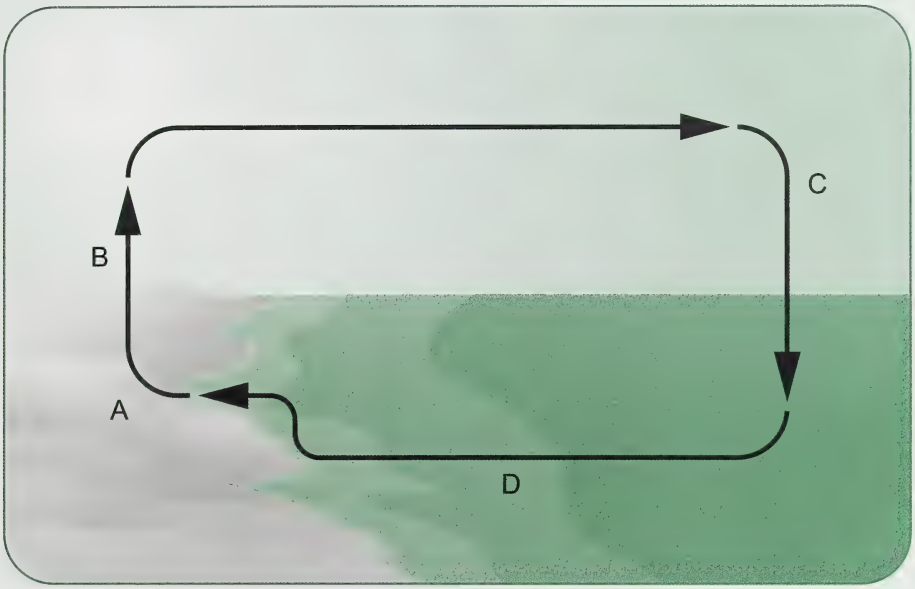
      The smoke will be drawn down the glass chimney on the left and up the glass chimney on the right.

10. a. Refer to the answers to question 2.a. in Part A.

    b. Refer to the answers to question 2.b. in Part A.

    c. Refer to the answer to question 2.c. in Part A.

11. Answers may vary. A sample answer is given.



A: The Sun warms the land and water, but the land warms more rapidly.
B: The air over the land warms and becomes less dense. Warm air rises.
C: The air over the water remains cooler. Cool air is more dense. Cool air sinks.
D: Cooler air moves toward the land to replace the warm air that has risen.

12. In a land breeze, the air rises over the water. Cooler air from over the land moves toward the water to replace the air that has risen. The warm air that rose over the water moves toward the land.

13. A land breeze is weaker than a sea breeze because there is less temperature difference between the land and the water at night.

14. It is warm to sit outside a cottage near the lake because warm air from over the lake rises then moves toward the land and cools and sinks down to the land. Although the air cools when it moves over the land, it is still warmer than the air over land that is further out from a lake.

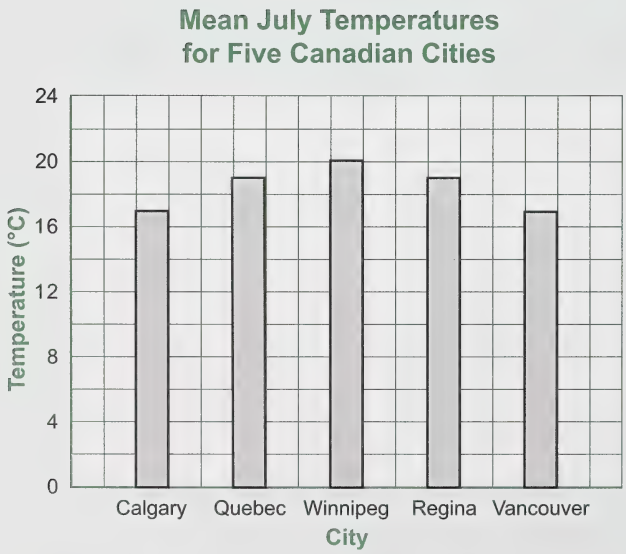
15. In a mountain breeze, the air flows from the mountains down to the valleys.

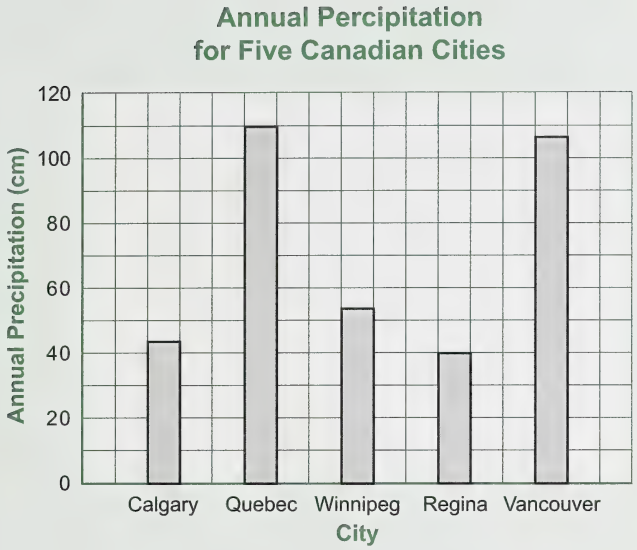
16. **Textbook questions 1, 2, and 3 of "What to Do," p. 96**

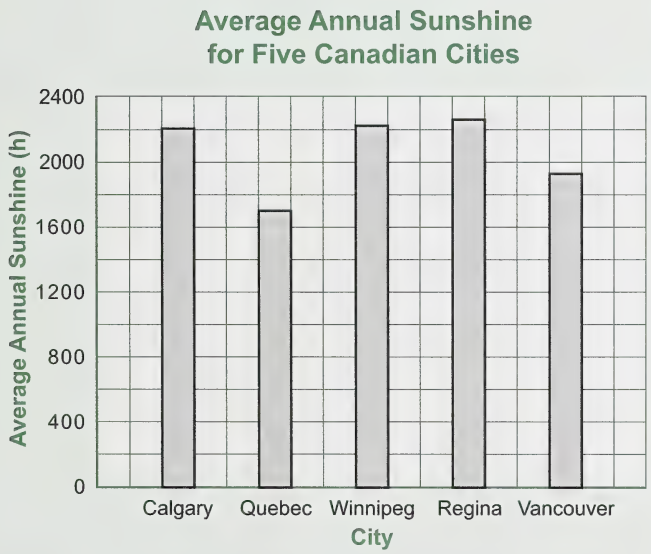
    1. The temperature of the air above the ocean is about the same as the temperature of the water. The water temperature somewhat controls the air temperature.

2. The cities are shown on the following map.

3.







17. a. **Textbook questions 1 and 2 of "Analyze," p. 96**

Answers may vary. Sample answers are given.

1. Nearness to the ocean makes temperatures less variable. It means there are less sunshine hours and more precipitation.

2. Vancouver is warmer than Calgary in the winter because the water of the Pacific Ocean moderates its temperature. In the winter, the water warms the air.

b. **Textbook question 3 of "Conclude and Apply," p. 96**

3. a. If you did not like cold temperatures, you would choose Vancouver.

   b. If you needed lots of sunshine and water, you would likely choose Winnipeg. The other two cities that get more water have much less sunshine.

   c. If damp weather causes problems, you would choose Regina.

18. Oceans moderate climate in cool weather by transferring heat to the air.

19. Oceans moderate climate in hot weather by absorbing heat from the air.

20. During cool days, convection occurs when warm air above the water rises, allowing the cooler air over the land to move over the ocean. The warmer air above the ocean then moves over the land, warming it up slightly. During warm days, convection occurs when warm air above the land rises, allowing the cooler air over the ocean to move toward land. The cooler air from the ocean moves inland, cooling the air over the land.

21. **Textbook question "Reading Check," p. 97**

    Answers may vary. A sample answer is given.

    The Pacific Ocean moderates Vancouver's climate. The water provides warming during the winter so the temperature is warmer. The water provides cooling in the summer so the temperature is cooler. The water keeps the temperature from varying as much as it would without the water.

22. **Textbook questions 1, 2, and 3 of "Check Your Understanding," p. 97**

    1. Winnipeg does not experience a large drop in temperature at night after a hot day because heat is transferred to the air from Lake Winnipeg. This keeps the nighttime temperature from dropping as much as in a city that has no large lake nearby.

    2. The steps of a land breeze are as follows:

       step 1: The water loses heat more slowly than the land. As a result, the water adds heat to the air over the water for a longer period of time, keeping the air over the water warmer.

       step 2: The warm air over the water rises.

       step 3: The air over the land is cooler. It is more dense and stays closer to the surface.

       step 4: Cool air flows toward the sea to replace the warm air that has risen.

3. It would be cooler on the beach. There would be a lake breeze that would cool the beach. This breeze wouldn't affect the temperature as much 20 km away.

Section 1: Lesson 5

1. The purpose of having a plastic or wooden handle on a cooking pot is so the handle will not get hot. This keeps you from burning your hand when you pick up the pot by the handle. Plastic and wood are not good conductors of heat. So, when the pot gets hot, the handle will not.

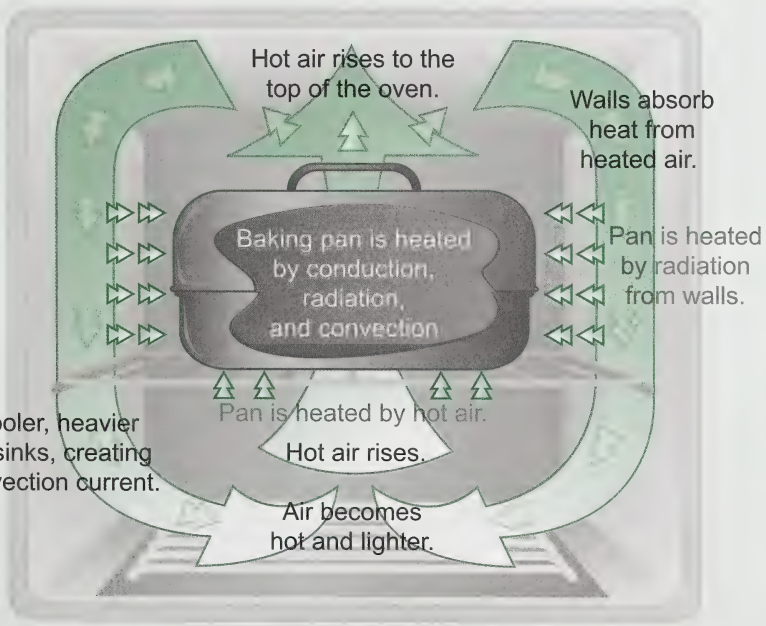
2. When soup first starts to heat, it heats at the bottom of the pot by conduction from the burner to the pot to the soup.

3. A cook will often stir a pot of soup after a few minutes of heating to mix the hotter soup at the bottom throughout the soup. This prevents the soup at the bottom from getting too hot and burning before convection starts.

4. The methods of heat transfer that are involved in transferring heat to food cooking in an oven are conduction, convection, and radiation.

5. **Textbook question "Reading Check," p. 99**

   Answers will vary. A sample answer is given.


Hot air rises to the top of the oven.
Walls absorb heat from heated air.
Baking pan is heated by conduction, radiation, and convection
Pan is heated by radiation from walls.
Pan is heated by hot air.
Cooler, heavier air sinks, creating convection current.
Hot air rises.
Air becomes hot and lighter.

6. Metal pots are used throughout the world for cooking because metal conducts heat very well.

7. The wetsuit is black, so it will absorb more heat from the Sun than a light-coloured one. Therefore, the guy in the wetsuit will warm up quicker.

8. The purpose of a radiator on a vehicle is to help remove excess heat from the engine.

9. A vehicle radiator mostly uses conduction to transfer heat from the motor to the coolant, to the radiator fins, and to the air moving through the fins.

10. The folded sheet of metal would get rid of heat faster because it has more surface area.

11. A vehicle cooling system uses a fan along with a radiator to cool the motor. The fan pulls air through the radiator to help take the heat away from the metal fins.

12. An air-cooled engine keeps itself from overheating by having air rush through metal fins that are part of the motor body. (**Note:** On many air-cooled engines, such as on lawn mowers and garden tractors, a fan attached to the main shaft of the motor is used to draw air through the metal fins.)

13. Thermal energy passes from your body to the water by conduction. The water evaporates (molecules of water moving into the air) and some thermal energy is passed into the air. This passing of thermal energy to the air makes you feel cool.

14. The thermal energy from food in a refrigerator first passes to the air inside the refrigerator.

15. The coolant in a refrigerator evaporates within the pipes after it has picked up thermal energy from the food.

16. The purpose of a compressor in a refrigerator is to convert the evaporated coolant back into a liquid.

17. The heat from the food in a refrigerator goes into the air in the room.

18. a. Total energy = 334 J + 418.6 J
= 752.6 J

The total amount of energy required to melt 1 g of ice and raise the temperature of the resulting water to 100°C is 752.6 J.

b. Number of times more energy = $\frac{2256\ \text{J}}{752.6\ \text{J}}$

= 3 (rounded to the nearest whole number)

It takes about three times more energy to convert 1 g of boiling water from liquid to steam than to melt 1 g of ice and raise the temperature of the resulting water to 100°C.

19. **Textbook questions 1 to 4 of "Check Your Understanding," p. 101**

1. The transfers of energy are as follows:

   - heating element to pot by conduction
   - pot to water by conduction
   - within the water by conduction and convection

2. Three kinds of energy transfer are used as follows:

   - Convection distributes hot air throughout the oven. The air heats the walls of the oven and the pan by conduction.
   - The walls radiate heat, which is absorbed by the bread pan and the bread.
   - Heat moves from the pan to the bread dough by conduction.

3. The shiny cup will keep the hot chocolate warm longer. Dark colours absorb heat better than shiny objects. Shiny objects reflect more heat than dark objects.

4. Gasoline engines can be cooled by air or liquid. An air-cooled system uses fins on the engine to move heat so it can get in contact with air that absorbs the heat. A water-cooled system uses a coolant to move heat from the engine to the radiator. The radiator transfers heat from the coolant to the air.

Section 1 Review

1.

N	Y	L	E	H	Y	P	O	T	H	E	R	M	I	A
O	G	G	H	Y	C	B	W	X	M	R	O	E	E	B
I	R	C	R	P	O	E	N	H	W	U	B	Z	T	P
T	E	U	A	E	U	Z	O	O	E	T	E	E	A	M
O	N	G	D	R	N	E	I	O	F	A	R	E	R	F
M	E	K	I	T	T	E	T	N	R	R	T	R	E	I
N	L	F	A	H	R	R	C	O	I	E	B	B	D	R
A	A	K	T	E	U	B	E	I	C	P	R	A	O	L
I	M	C	I	R	M	D	V	T	T	M	O	E	M	H
N	R	Q	O	M	F	N	N	C	I	E	W	S	W	Y
W	E	S	N	I	O	A	O	U	O	T	N	A	Y	Z
O	H	L	E	A	R	L	C	D	N	S	B	I	C	H
R	T	D	U	Q	D	N	U	N	B	O	I	A	K	M
B	S	O	A	O	L	A	V	O	I	S	I	E	R	K
R	L	Z	D	Y	J	G	Y	C	D	D	P	J	K	M

2. a. **Textbook question 1 of "Reviewing Key Terms," p. 102**

    1. a. The sum of all the kinetic energies of an object is its **heat**.

    b. The average of all the kinetic energies of an object is its **temperature**.

    c. The energy due to motion of particles in an object is its **kinetic energy**.

    d. A process of heat transfer that occurs when two objects are in contact with each other is **conduction**.

    e. The process that releases heat when two objects rub together is **friction**.

    f. The first person to observe a sign of molecular motion was **Robert Brown**.

    g. A process of heat transfer that involves the circular flow of air or liquids is called **convection**.

    h. A process of heat transfer that involves electromagnetic waves is called **radiation**.

i. A wind that occurs as a result of air flowing from the land to the sea is called a **land breeze**.

j. Oceans keep land near them from having temperature extremes. We say that oceans **moderate** temperatures.

k. A wind that occurs as a result of air flowing from the sea to the land is called a **sea breeze**.

l. A jiggling motion of small particles in water is called **Brownian motion**.

b. **Textbook questions 4 and 6 of "Understanding Key Ideas," pp. 102 and 103**

4. a. This is an example of convection. There is some heating due to radiation as well.

b. This is an example of radiation.

c. This is an example of conduction.

6. At night, the nearby water releases heat to the air that it absorbed during the day. This moderates the nighttime temperature of Toronto.

c. **Textbook questions 9 and 10 of "Problem Solving/Applying," p. 103**

9. Temperature is a measure of the average kinetic energy of the particles in an object. Since the 40°C block has a higher temperature, it has the higher average kinetic energy among its particles.

10. These objects' particles have the same average kinetic energies. We know this because their temperatures are the same. The larger object has more heat since there are more particles. The heat or thermal energy is the sum of the energies of the particles in an object. Same average energy but with more particles gives a larger sum.

Section 2: Lesson 1

1. You would want shoes when stranded on a tropical island because the sand on the beach can get very hot from the Sun. It can get hot enough to burn your bare feet.

2. Data will vary. Sample data is given.

PART 1: LIQUIDS

Substance	Starting Temperature (°C)	Finishing Temperature (°C)	Time Taken to Raise the Temperature 30°C
water	21°C	51°C	4 min 59 s
motor oil	21°C	51°C	2 min 50 s
vegetable oil	21°C	51°C	2 min 36 s

PART 2: SOLIDS

Substance	Starting Temperature (°C)	Finishing Temperature (°C)	Time Taken to Raise the Temperature 30°C
glass marbles	21°C	51°C	2 min 20 s
sand	21°C	51°C	2 min 0 s
iron shot or nails	21°C	51°C	1 min 48 s

3. a. **Textbook questions 1 to 4 of "Analyze," p. 107**

    1. The water took the longest time to increase in temperature by 30°C.

    2. The oils took about the same time to heat up. This is because they are similar substances.

    3. The glass marbles took the longest time to increase in temperature by 30°C.

    4. The glass marbles and the sand took about the same time to rise in temperature by 30°C. This is because glass and sand are similar. Glass is made from sand.

    b. **Textbook question 5 of Conclude and Apply," p. 107**

    5. a. Yes, the kind of material being heated affects the amount of heat needed.

        b. The water took longer to heat up than the two oils. Also, the liquids took longer to heat up than the solids.

4. a. 1°C temperature rise = 4.19 J

$\therefore$ 10°C temperature rise = 10 x 4.19 J
= 41.90 J

To raise 1 g of water 10°C, 41.90 J of energy is needed.

b. 1°C temperature rise = 4.19 J

$\therefore$ 25°C temperature rise = 25 x 4.19 J
= 104.75 J

To raise 1 g of water 25°C, 104.75 J of energy is needed.

c. 1°C temperature rise = 0.84 J

$\therefore$ 10°C temperature rise = 10 x 0.84 J
= 8.40 J

To raise 1 g of glass 10°C, 8.40 J of energy is needed.

5. a. Raise 1 g of water 1°C = 4.19 J

$\therefore$ Raise 10 g of water 1°C = 10 x 4.19 J
= 41.90 J

To raise 10 g of water 1°C, 41.90 J of energy is needed.

b. Raise 1g of water 1°C = 4.19 J

$\therefore$ Raise 35 g of water 1°C = 35 x 4.19 J
= 146.65 J

To raise 35 g of water 1°C, 146.65 J of energy is needed.

c. Raise 1 g of glass 1°C = 0.84 J

$\therefore$ Raise 20 g of glass 1°C = 20 x 0.84 J
= 16.80 J

To raise 20 g of glass 1°C, 16.80 J of energy is needed.

6. a. Raise 1 g of motor oil 1°C = 2.00 J

   ∴ Raise 5 g of motor oil 1°C = 5 x 2.00 J
   = 10 J

   ∴ Raise 5 g of motor oil 10°C = 10 x 10 J
   = 100 J

   To raise 5 g of motor oil 10°C, 100 J of energy is needed.

   b. Raise 1 g of glass 1°C = 0.84 J

   ∴ Raise 2 g of glass 1°C = 2 x 0.84 J
   = 1.68 J

   ∴ Raise 2 g of glass 5°C = 5 x 1.68 J
   = 8.4 J

   To raise 2 g of glass 5°C, 8.4 J of energy is needed.

7. a. Glass has the highest specific heat of the three items tested. Glass 3 will have the warmest water.

   b. The glass of vegetable oil with the glass object will have the warmest oil.

   c. Other things being the same, the oil temperature will be higher because oil has a lower specific heat capacity than water.

8. Water has a higher heat capacity than land.

9. Land heats up and cools quicker than water.

10. When the Sun is shining, water absorbs heat and slows the rise of temperatures of the surrounding land area. At night, water releases heat and slows the cooling in the surrounding area.

11. **Textbook questions 1 to 4 of "Check Your Understanding," p. 110**

    1. a. Beaker B will require a greater input of thermal energy. There is more water in Beaker B, so it will require more energy to warm it from 10°C to 20°C.

       b. Beaker B will require a greater input of thermal energy. It will require more energy to warm water from 10°C to 30°C than only to 20°C.

c. Beaker A will require a greater input of thermal energy. Water has a higher specific heat capacity than vegetable oil. Therefore, more energy is needed to raise water 10°C than is needed to raise vegetable oil 10°C.

2. Beaker A will require a greater input of thermal energy. The specific heat capacity of water is considerably greater than that of sand. Therefore, more energy is needed for an equal increase in temperature. However, you may want to consider that 500 mL of sand has a mass of about 1.25 kg, whereas 500 mL of water has a mass of only 0.5 kg. But this is still not enough of a difference to overcome the much greater specific heat of water. Keep this in mind when comparing other substances.

3. During the day, the Sun's energy can raise the temperature of the sand faster than that of water. This is because sand has a much lower specific heat capacity than water. During the night, the air can cool the sand more quickly than the water. Again, this is because water has a larger specific heat capacity.

4. Water is a better coolant because it can absorb more heat than vegetable oil. This suggests that a water-based coolant should be used in car radiators. Water is inexpensive, readily available, and will do the job well. However, the use of ethylene glycol with about 40% water gives the maximum overheating and freezing protection and prevents rusting.

12. The substance that you see above the spout of a boiling kettle is condensed water vapour.

Section 2: Lesson 2

1. The material that is used to reduce heat loss in a building is called insulation.

2. Insulation in a building keeps heat **in** during the winter and keeps heat **out** during the summer.

3. *R-value* is the measure of how well a material slows heat transfer.

4. Total R-value = 4.25 + 1.25
   = 5.50

   The total R-value of the two insulating materials is 5.50.

5. Answers may vary. A sample prediction is given. The types of insulation from best insulator to the poorest is as follows:

   foam pellets, poured insulation, bubble wrap, wood shavings, aluminum foil

6. Answers will vary. Sample data is given.

Insulation Material	Ice Cube Initial Mass (g)	Ice Cube Final Mass (g)	Ice Cube Mass Lost (g)
wood shavings	68	52	16
foam pellets	66	56	10
bubble wrap	69	55	14
poured insulation	68	57	11
aluminum foil	67	47	20
empty can	68	46	22

7. a. **Textbook questions 1 to 4 of "Analyze," p. 113**

Answers will vary. Sample answers are given.

1. The ice melted the most in the empty container. The ice melted the least in the container with the foam pellets. The poured insulation was almost the same as the foam pellets.

2. The container in which the ice melted the least had the best insulation (the container with the foam pellets or the poured insulation).

3. The aluminum provided the poorest insulation.

4. a. The same size and type of container and the size of the ice cube are factors that were controlled best.

   b. The thickness of the insulation and the time between taking the ice cubes out of the freezer and insulating them may vary. Also, the time between taking the ice cubes out and weighing them may vary.

b. **Textbook questions 5 and 6 of "Conclude and Apply," p. 113**

5. The best materials to get the ice to the carnival would be the foam pellets or the poured insulation.

6. The blocks would have to be separated so they don't stick together. Also, poured insulation will stick to the ice blocks and may have to be washed off. Foam chips may need a container that separates the blocks and allows the chips to be poured in around each block. Bubble wrap may work well since it can be wrapped around each block. Some insulation materials are cheaper than others. Materials such as straw, wood shavings, or wood sawdust have been used for many years to transport ice.

c. **Textbook question 8 of "Extend Your Knowledge," p. 113**

8. Yes, the best insulating material for keeping something cold will also be good for keeping something hot.

8. Data will vary. Sample data is provided.

Glass	Starting Temperature	Temperature After 30 min
glass only	54°C	40°C
glass with aluminum foil wrap	54°C	45°C

9. **Textbook questions 1 and 3 of "What Did You Find Out?," p. 114**

1. The beaker without the aluminum foil on it lost the most heat after 30 min.

3. The foil reduces heat transfer. It can reduce radiation of heat. Since the aluminum foil doesn't fit perfectly to the glass, it can reduce the heat conducted to the surrounding air as well. A dead-air space is formed between the glass and the aluminum foil, reducing conductivity.

10. The water in the container with the shiny side of the aluminum foil facing the inside should be slightly warmer than water in the container with the shiny side of the aluminum foil facing the outside.

11. Answers will vary. Things that can be done around the home to save energy include the following:

    - Seal all air leaks around windows and doors with weather stripping, caulking, or tape.
    - Add extra insulation to the ceiling (if it is accessible) to reduce energy consumption significantly.
    - Replace windows or doors. This can be expensive.
    - Add Styrofoam™ insulation and redo the exterior. This is very expensive. The cost recovery is definitely over the long term.

12. Convection currents will carry heat to the outside. Using insulation stops these convection currents. Large spaces allow for thick insulation which will provide a large R-value.

13. a. The R-value of 25 mm of air space with reflective surface is 5.54.

    Determine the R-value of 50 mm of rigid urethane foam.

    The R-value of 25 mm of rigid urethane foam is 7.50. Because 50 mm is 2 times as much as 25 mm, the R-value of 50 mm will be 2 times larger.

    2 x 7.50 = 15.00

    The R-value of 50 mm of rigid urethane foam is 15.00.

    Now, find the total R-value.

    Air space with reflective surface + Rigid urethane foam = 5.54 + 15.00
    = 20.54

    The total R-value is 20.54.

b. First, determine the R-value of 12.5 mm of solid wood.

The R-value of 25 mm of solid wood is 1.25. Because 12.5 mm is half of 25 mm (12.5 ÷ 25 = 0.5), the R-value of 12.5 mm will be half.

0.5 x 1.25 = 0.625

The R-value of 12.5 mm of solid wood is 0.625.

Second, determine the R-value of 150 mm of fibreglass.

The R-value of 25 mm of fibreglass is 4.25. Because 150 mm is 6 times as much as 25 mm (150 ÷ 25 = 6), the R-value of 150 mm will be 6 time larger.

6 x 4.25 = 25.50

The R-value of 150 mm of fibreglass is 25.50.

Now, find the total R-value.

Solid wood + Fibreglass = 0.625 + 25.50
= 26.125 or 26.13

The total R-value is 26.13.

14. Insulation with an R-value of 30 would allow $\frac{1}{30}$ of the heat to pass through.

15. The material used on the inside of the insulating layer of an insulated envelope is foil with the shiny surface toward the pizza.

16. a. The air spaces help prevent heat transfer by conduction.

    b. The partial vacuum helps prevent heat transfer by convection.

    c. The silver surfaces help prevent heat transfer by radiation.

17. Plastic is a common insulating material on kitchen appliances because it is a poor conductor of heat. Also, plastic can be molded to any form and is inexpensive.

18. You want to have a freezer with walls that are well insulated so the freezer will be energy efficient.

19. **Textbook questions 1 to 6 of "Check Your Understanding," p. 119**

    1. R-values add together. Find the value of a combination by adding the individual values.

       a. R-value = Air space + Expanded polystyrene
          = 2.04 + 3.96
          = 6.00

       b. R-value = Rigid urethane foam + Solid wood
          = 7.50 + 1.25
          = 8.75

       c. R-value = Air space + Concrete
          = 2.04 + 0.19
          = 2.23

    2. Shavings get better results than solid wood because they trap air pockets. This reduces the heat loss due to conduction.

    3. Hot air rises. The temperature difference between the ceiling and the attic is larger than the difference between the walls and the outside. Heat moves faster when there is a larger temperature difference. More insulation in the attic will reduce this increased heat loss. (The amount of space available in an attic is greater than in walls and insulation is generally easy to blow into an attic are other possible reasons.)

    4. Foil reduces radiated heat loss. This makes it a useful insulating material.

    5. a. Windows and doors both have relatively low R-values. This means more heat will escape through them than through better-insulated parts of the house. Also, windows and doors have small spaces around them where air can move through.

       b. Heat transfer is slowed by reducing convection, conduction, and radiation. For windows, this can be done by using double- and triple-sealed units that are well-caulked into the frames, have dead-air spaces, and have specially coated surfaces. Doors that have urethane foam between panels will reduce heat loss.

    6. Handles are made of non-metals because metals conduct heat well. The non-metals do not conduct heat well and, therefore, keep the handles cooler for your hands.

Section 2: Lesson 3

1. Answers may vary. Sample answers are given.

   windproof jacket: The jacket prevents air exchange and helps keep a layer of warm air near the body.

   wool mitts: Air is trapped in the knitting of the mitts. This prevents heat from moving by conduction and limits convection. Wool also helps you keep dry.

   wool sweater: Air is trapped in the knitting of the sweater. This prevents heat from moving by conduction and limits convection. Wool also helps you keep dry.

   cotton turtleneck: This provides an additional layer of clothing. There is a small amount of air between layers that provides additional insulating value.

2. You want to wear several layers in cold weather because layers trap air between and help keep you warm. Also, if you get too warm and start to sweat, you can remove a layer so you can cool down and allow the moisture to escape.

3. Next to your body, you want to wear clothing that allows moisture to pass through. If moisture cannot escape from your body, you will feel cold.

4. The Caribou Inuit wear the inner suit of clothing with the fur turned to the inside because the fur will absorb moisture from the person's body and transfer it away from the body.

5. The Caribou Inuit wear the outer suit with the fur to the outside because the fur blocks the wind and provides insulation to keep the cold out.

6. Caribou fur is dense, which helps keep out the cold and the wind. Also, each hair is hollow, so air is trapped in each hair to provide additional insulation.

7. The large hood with fur trim provides a protected space where air is warmed up before the person breathes it into the lungs. The fur used on the trim keeps ice from forming due to condensation of moist air breathed out into the cold.

8. The seal skin boots are waterproof and, therefore, keep your feet dry.

9. **Textbook questions 1 to 5 of "Evaluate," p. 122**

   Answers will vary. Sample answers are given.

   1. Mitts, hats, and socks are items that might get wet. Carry extras of these.

   2. One extra sweater per person and perhaps splash pants or light ski pants.

   3. Sweaters, socks, and down vests are examples of insulators. Nylon, plastic, and GORE-TEX® are examples of windproof materials.

   4. You should include dried fruit, granola, nuts (Watch out for allergies.), chocolate, and dried soup mix as energy sources for people.

   5. A clean empty can and candles or a pocket stove (uses a compressed cube for fuel) could be used to melt snow.

10. **Textbook questions 1 to 5 of "What Did You Find Out?," p. 123**

    1. No, the temperature on the thermometer in the black sock was higher.

    2. The black sock absorbed the heat faster.

    3. The black sock would be hotter if worn on a sunny day and if exposed to the Sun.

    4. White socks would be cooler for your feet.

    5. The light-coloured robes do not absorb as much heat. Therefore, the person wearing it would be cooler than a person in a dark-coloured robe.

11. Summer cabins generally are not insulated well. The black shingles would absorb more heat and radiate it into the cabin. In the summer, you usually want to reduce heat, not increase it.

12. Many contractors do not want to put black or dark-coloured asphalt shingles on houses because dark-coloured asphalt shingles will absorb more heat and start to curl up more quickly.

13. A firefighter's suit is treated with fire-retardant chemicals so they do not burn.

14. A firefighter can suffer from heat stroke when fighting a fire even in winter if the temperature within his or her suit gets too high.

15. Scientists test firefighter suits using a mannequin named Harry. Harry is dressed up in the suit and then set on fire. Harry has 110 sensors that measure the amount of heat transfer through the suit. Any problem areas in the suit would show up on the sensors.

16. A diver's suit should fit snugly so the cold water does not get between the suit and the diver's body.

17. Dive suits are made from neoprene with nitrogen bubbles trapped within the neoprene. Neoprene is a rubber-like material.

18. The purpose of adding titanium to the fabric on the inside of a diver's suit is to reflect body heat back to the body.

19. **Textbook questions 1 to 6 of "Check Your Understanding," p. 125**

    1. Answers may vary. A sample answer is given.

       head: To keep my head warm, I will wear a toque and a jacket hood. The hood may help warm the air before I breathe it in.

       hands: To keep my hands warm, I will wear mitts so the thumb can be put into the main body and share heat with the fingers and palm of the hand.

       feet: To keep my feet warm, I will wear insulated boots and woolen socks. The socks will absorb moisture.

       legs: For my legs, I will wear long underwear and windproof pants.

       chest: To keep my chest and back (torso) warm, I will wear an undershirt, sweater, and jacket. The layers will help provide better insulation from the cold. Other layering methods would work as well.

       neck and face: I will wear a scarf to cover my face and neck. It can cover what the jacket and toque miss.

    2. The pictures on page 125 suggest nearly complete body coverage. A neoprene dive suit with gloves, boots, and hood should be worn when diving in cold water.

    3. Answers will vary. There are many good insulating materials that can protect you on a cold day. Down, fleece, and wool are good insulators. Windproof materials as an outer shell would help as well.

4. Answers will vary. Ways Inuit clothes are designed to keep heat in are as follows:

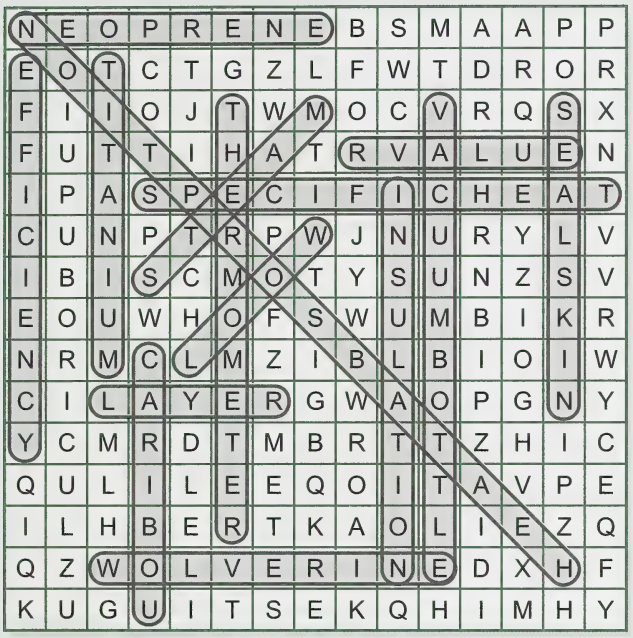
    - Fur is worn next to the body to let body moisture exit. This layer is also an insulating layer, trapping body heat inside.
    - Fur is worn as an outer layer. It again acts as insulation and a windbreak. Also, the fur is tough and somewhat water-resistant.
    - The hood keeps the head and face warm. It also helps warm the air being inhaled.
    - The hood is edged with fur that doesn't let moisture condense (like wolverine, wolf, or dog fur.)
    - Parkas are extra large to let the arms come inside to get warm.
    - Up to four layers of footwear are worn. An outer layer of seal skin makes the footwear waterproof.
    - Mitts are worn, which provide much the same protection for hands as the parkas do for the body.

5. In cold climates, large amounts of heat can be lost through the head. It needs to be covered to keep warm. In hot climates, the head needs to be covered to keep the Sun from overheating the head.

6. In summer, you wouldn't likely need sand or extra weight for traction. You also would be able to carry food and water without worry about them freezing. You would, however, have to worry about some food spoiling in the heat. You still should have clothing. It would need to keep you warm and dry and to protect you from the Sun. You might want to carry insect repellant, sunscreen, and something like an umbrella to provide additional protection from the Sun.

Section 2 Review

1.



N	E	O	P	R	E	N	E	B	S	M	A	A	P	P
E	O	T	C	T	G	Z	L	F	W	T	D	R	O	R
F	I	I	O	J	T	W	M	O	C	V	R	Q	S	X
F	U	T	T	I	H	A	T	R	V	A	L	U	E	N
I	P	A	S	P	E	C	I	F	I	C	H	E	A	T
C	U	N	P	T	R	P	W	J	N	U	R	Y	L	V
I	B	I	S	C	M	O	T	Y	S	U	N	Z	S	V
E	O	U	W	H	O	F	S	W	U	M	B	I	K	R
N	R	M	C	L	M	Z	I	B	L	B	I	O	I	W
C	I	L	A	Y	E	R	G	W	A	O	P	G	N	Y
Y	C	M	R	D	T	M	B	R	T	T	Z	H	I	C
Q	U	L	I	L	E	E	Q	O	I	T	A	V	P	E
I	L	H	B	E	R	T	K	A	O	L	I	E	Z	Q
Q	Z	W	O	L	V	E	R	I	N	E	D	X	H	F
K	U	G	U	I	T	S	E	K	Q	H	I	M	H	Y

2. a. **Textbook question 1 of "Reviewing Key Terms," p. 126**

1. Answers will vary. Sample answers are given.

a. The cold spoon absorbs heat from the hot chocolate.

b. The high specific heat capacity of the water in the hot chocolate keeps it warm for a long time.

c. and d. The Styrofoam™ cup has a high R-value and provides good insulation to keep the hot chocolate hot.

e. A vacuum bottle would provide better insulation and keep the hot chocolate hot longer.

b. **Textbook questions 2 to 5 of "Understanding Key Ideas," p. 126**

2. a. X would be placed near the top of the chart. Large heat capacity is at the top of the chart.

   b. Y would be placed near the bottom of the chart. Small heat capacity is at the bottom of the chart.

3. The copper pot heats more quickly. Copper has a lower specific heat capacity than iron. Less energy is needed to heat it, so less time is needed to reach any specific temperature.

4. Hollow, tubular hair is better for very cold climates. The trapped air provides very good insulation.

5. It is better to wear mittens on a cold day. You can keep all of your fingers and your thumb together. They then share their heat. Also, the mittens have fewer places for heat loss as there is less stitching.

c. **Textbook questions 8 and 10 of "Problem Solving/Applying," pp. 126 and 127**

8. The cup with the metal spoon cools more quickly. The spoon will conduct additional heat from the hot chocolate.

10. Packing fibreglass reduces its efficiency. Fibreglass works by creating tiny pockets of air. Packing it reduces the number of pockets and will reduce how well it works.

d. **Textbook questions 13, 14, and 15 of "Critical Thinking," p. 127**

13. The high specific heat of hydrogen makes it a very good cooling agent.

14. Amsterdam is beside the North Sea. Edmonton is nowhere near a large body of water, like the North Sea. The North Sea will moderate Amsterdam's climate.

15. The blankets provide insulation. The water has a high specific heat capacity. When the air cools, the water does not cool off as quickly and does not freeze if the frost is light. The water gives off heat to the plants, protecting them.

Section 3: Lesson 1

1. Answers will vary. Sample data is given.

LEFT SIDE: MASS x DISTANCE		
Hanging Mass (g)	Distance from Centre (cm)	Mass x Distance (g•cm)
50	40	2000

RIGHT SIDE: MASS x DISTANCE		
Counterweight (g)	Distance from Centre (cm)	Mass x Distance (g•cm)
50	40	2000
100	20	2000
200	10	2000
500	4	2000

2. Mass x Distance is the same for each.

3. The relationships can be written as follows:

   15 = 1 x 15 14 = 2 x 7 12 = 4 x 3

   The product of the single penny and its distance from the centre is equal to the product of each group of pennies and their distances from the centre.

4. **Textbook question "Reading Check," p. 130**

   Energy is the ability to do work.

5. Answers will vary. Sample data is given.

Situation	Force (N)	Height (cm)	Distance Moved (cm)
lifted block up onto three books	4.0	6	6
slid block up inclined board onto three books	1.5	6	100
lifted block up onto six books	4.0	12	12
slid block up inclined board onto six books	2.5	12	100

6. **Textbook questions 1 to 4 of "What Did You Find Out," p. 131**

    1. It takes less force to slide the block up the inclined plane.

    2. Increasing the angle by using more books increases the force needed. The force needed was 1.5 N for the angle with three books and 2.5 N for the angle with six books.

    3. With a ramp, you use less force; that is the gain. However, you need to apply the force over a longer distance; that is the loss.

    4. Reducing friction would improve this machine. Putting oil or wheels on the ramp (the board) could reduce friction.

7. A force, in science, is a push or a pull.

8. An object has to be moved for the process to be called work.

9. Work = Force x Distance
   $W = F \times d$

10. A newton-metre is the amount of work done when a force of 1 N is used to move an object 1 m.

11. A joule is equal to one newton-metre (1 J = 1 N•m).

12.

Situation	Force (N)	Height (cm)	Distance Moved (cm)	Work (J)
lifted block up onto three books	4.0	6	6	0.24
slid block up inclined board onto three books	1.5	6	100	1.50
lifted block up onto six books	4.0	12	12	0.48
slid block up inclined board onto six books	2.5	12	100	2.50

13. a. It takes more work to slide the block up the incline onto three books than to lift the block up onto the three books.

    b. It takes more force to lift the block up onto the three books than to slide the block up the incline onto the three books.

    c. Yes, the results are the same for the situation involving the six books.

14. a. A joule (J) and a newton-metre (N•m) are both units used to record the amount of work done (1 J = 1 N•m).

    b. The force, *F*, is 50 N. The distance, *d*, is 2 m.

    $W = F \times d$
    $W = 50\ \text{N} \times 2\ \text{m}$
    $W = 100\ \text{N•m}$ or $100\ \text{J}$

    To lift the weight, 100 J of work is done.

    c. The force, *F*, is 75 N. The distance, *d*, is 4 m.

    $W = F \times d$
    $W = 75\ \text{N} \times 4\ \text{m}$
    $W = 300\ \text{N•m}$ or $300\ \text{J}$

    To push the block, 300 J of work is done.

d. The force, F, is 5 N. The distance, d, is 4 m.

$W = F \times d$
$W = 5\ \text{N} \times 4\ \text{m}$
$W = 20\ \text{N•m}$ or $20\ \text{J}$

To push the block, 20 J of work is done.

e. The distance, d, is 2 m. The work done, W, is 500 N•m.

$$W = F \times d$$
$$500\ \text{N•m} = F \times (2\ \text{m})$$
$$\frac{500\ \text{N•m}}{2\ \text{m}} = \frac{F \times (2\ \text{m})}{2\ \text{m}}$$
$$250\ \text{N} = F$$
$$F = 250\ \text{N}$$

To lift the grain, 250 N of force is used.

15. Examples of an inclined plane include the following:

- ramps leading to buildings, sidewalks, or highways
- switchbacks on a steep mountain road
- wood screws
- screw-on bottle caps

16. An inclined plane is a simple machine involving a rise in surface over a distance.

17. Work is done when a force is applied to an object and the object moves.

18. No work is done by the cyclist in Figure 7.10 because the cyclist is not applying any force.

19. Work is done by the cyclist in Figure 7.11 because the cyclist is applying a force over a distance. The cyclist is moving the pedals through a distance on each turn of the pedals.

20. **Textbook questions 1 to 4 of "Check Your Understanding," p. 133**

1. a. Work is being done. The books are moved up from the floor to the desk.

b. Work is being done. The bag is moving down the hallway in the same direction as the force (walking) being applied.

c. Answers may vary. The reasoning is what is important.

   i) No work is being done because nothing is moving.

   ii) Work is being done. Pages in books are being moved. Blood is being moved more quickly inside the body. Pencils or pens are moving as notes are jotted down.

d. Work is being done. The track on the treadmill is moving. The pedals on the bike are moving.

e. Work is being done. The student's body is moving.

2. A joule is equivalent to a newton-metre.

3. Energy is the ability to do work. Work is done when a force moves an object; this will require energy.

4. There are many inclined planes, like a wheelchair ramp, boat launch, sloping road, loading ramp, wedge, chisel, axe head, screw, and threaded bolt.

Section 3: Lesson 2

1. The *fulcrum* is the pivot point on a lever.

   The *load* is the object that the lever moves.

   The *effort* is the force that is needed to move the object.

   The *load distance* is the distance from the fulcrum to the load.

   The *effort distance* is the distance from the fulcrum to the effort.

2. In Figure 7.12, the load distance is represented by the letter "a."

3. In a first class lever, the fulcrum is located between the effort and the load.

4. Examples of first class levers include the following:

   - pry bars
   - nail pullers (pull bar or hammer)
   - scissors
   - tin snips
   - pliers
   - manual hedge clippers

5. a. The mass is raised 10 cm.

   b. The mass is raised 5 cm.

   c. The mass is raised 2.5 cm.

6. a. Product = 50 x 10
   = 500

   b. Product = 100 x 5
   = 500

   c. Product = 200 x 2.5
   = 500

7. The product of the mass times the distance moved is the same on both sides for the three masses used on the right.

8. The effort distance is larger than the load distance when a mass that is larger than the effort is moved.

9. For a balanced lever, the effort times the effort distance is exactly the same as the load times the load distance.

10. In a second class lever, the effort is on one end, the load is in the middle, and the fulcrum is on the other end.

11. Examples of second class levers include the following:

    - wheelbarrows
    - can openers
    - bottle openers
    - nutcrackers

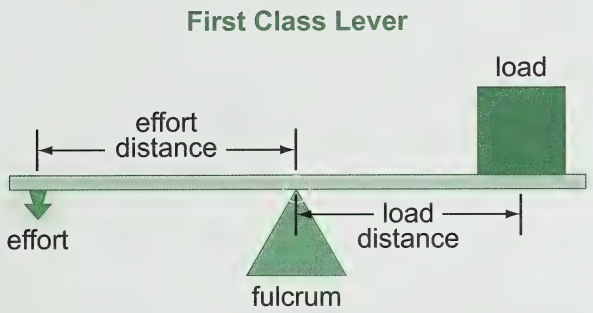
12. In a third class lever, the load is on one end, the effort is in the middle, and the fulcrum is on the other end.

13. Examples of third class levers include the following:

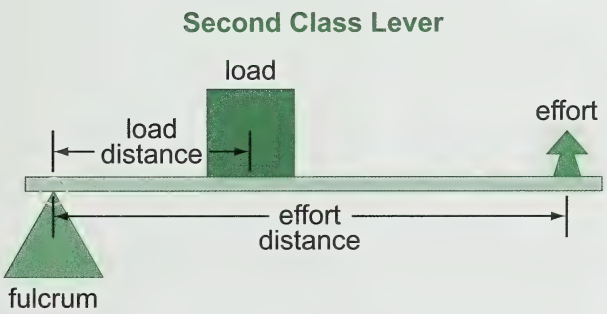
    - fishing poles
    - axes
    - badminton, tennis, or squash rackets

14. A third class lever is different from a second class lever in that the load and effort are switched.

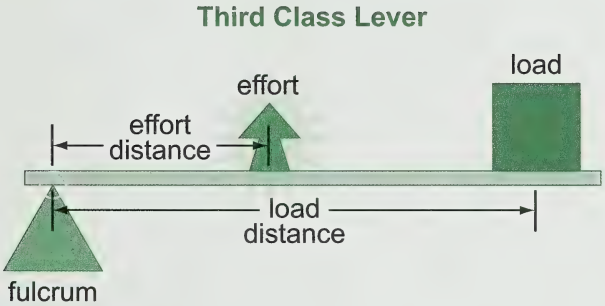
15. a.



b.



c.



16. The triceps muscle provides the effort force when the arm is used as a first class lever.

17. The biceps muscle provides the effort force when the arm is used as a third class lever.

18. When the arm is used as a first class lever, the effort is behind the elbow, so the fulcrum is in the middle. This is the same as in the diagram in the answer to 15.a. When the arm is used as a third class lever, the effort is between the fulcrum and the load. This is the same as in the diagram in the answer to 15.c.

19. Third class levers are used as distance and speed multipliers.

20. Examples of distance and speed multipliers include the following:

    - fishing rods
    - tennis rackets
    - hockey sticks
    - axes
    - mallets (hammers)

21. The first and second class levers are commonly used as force multipliers.

22. When a lever is used as a force multiplier, the effort distance is large and the load distance is small.

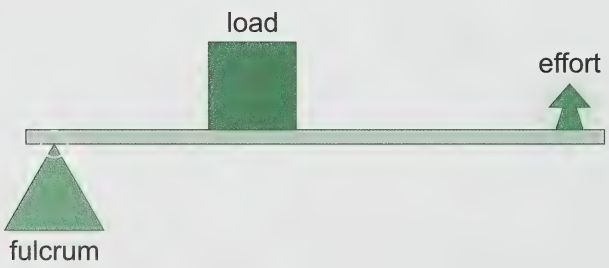
23. Differences between a distance multiplier and a force multiplier include the following:

    - The effort distance is small in the distance multiplier and large in the force multiplier.
    - The load distance is large in the distance multiplier and small in the force multiplier.
    - The distance multiplier uses a third class lever; the force multiplier uses first and second class levers.

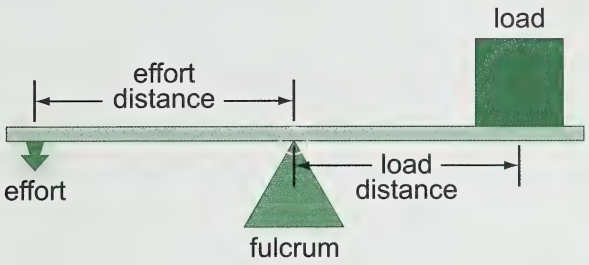
24. **Textbook questions 1 to 6 of "Check Your Understanding," p. 139**

    1. It can reduce the effort required to do the work.

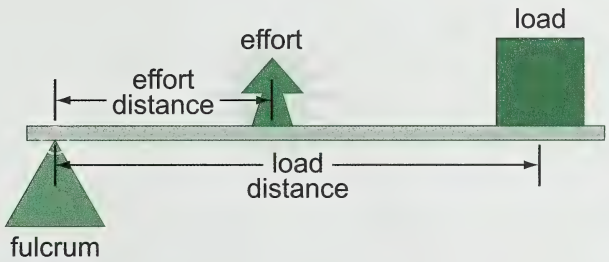
    2.



3. In a first class lever, the effort and load are on opposite sides of the fulcrum. The effort and load also move in opposite directions.



In a third class lever, the effort and load are on the same side of the fulcrum. The effort and load move in the same direction.



4. When you swing an axe, you are operating it as a third class lever. If the axe handle is longer, the load distance can be longer. The resulting force will be greater with a longer handle.

5. Answers will vary. A sample answer is given.

First Class Levers

- elbow and triceps (force multiplier)
- scissors (force multiplier)
- crowbar (force multiplier)
- pliers (force multiplier)

Second Class Levers

- foot (force multiplier)
- wheelbarrow (force multiplier)
- bottle opener (force multiplier)
- nutcracker (force multiplier)

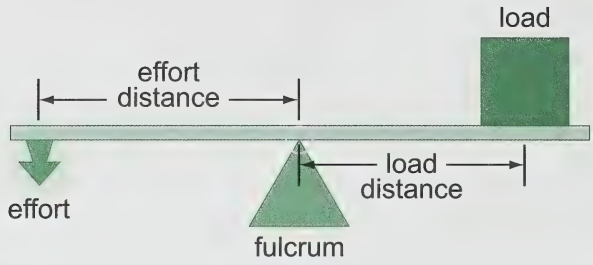
Third Class Levers

- elbow and biceps (distance multiplier)
- shovel (distance multiplier)
- hockey stick (distance multiplier)
- broom (distance multiplier)

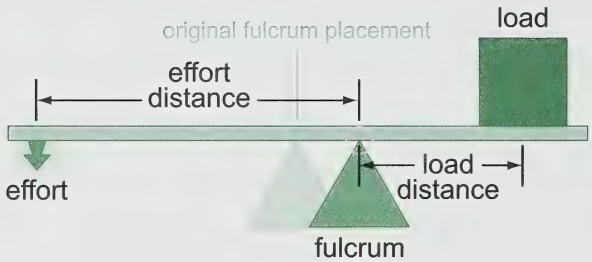
6. When the fulcrum is moved, the effort distance and load distance change. Each class of lever gives different changes. The following shows the results by class of lever.

First Class Lever

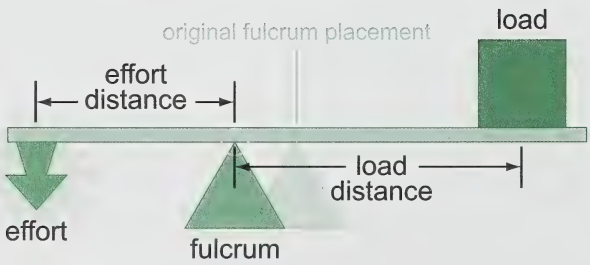
Here is a general diagram of a first class lever.



When the fulcrum moves toward the load, the load distance decreases and the effort distance increases the same amount.

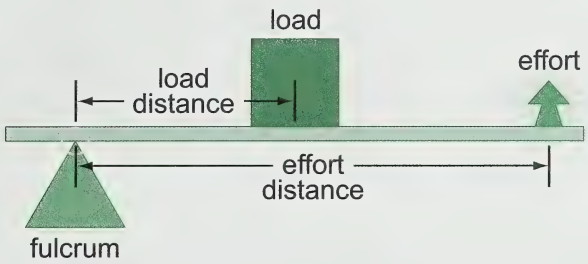


When the fulcrum moves toward the effort, the load distance increases and the effort distance decreases the same amount.

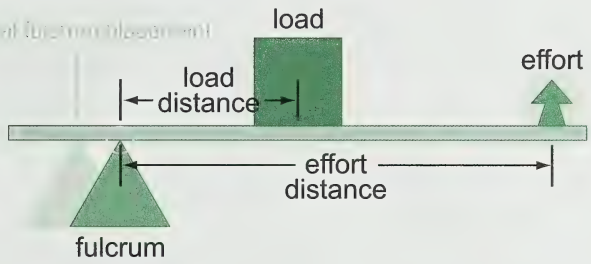


Second Class Lever

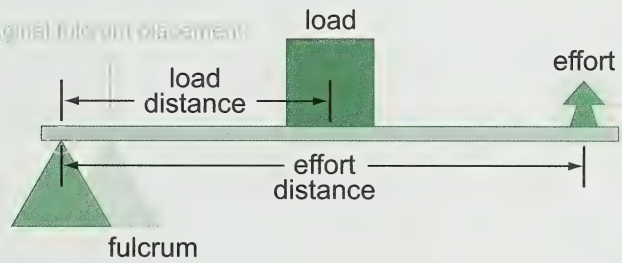
Here is a general diagram of a second class lever.



When the fulcrum moves toward the load and the effort, both load distance and effort distance decrease the same amount.

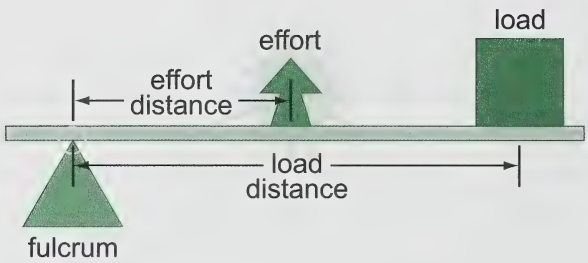


When the fulcrum moves away from the load and the effort, both load distance and effort distance increase the same amount.

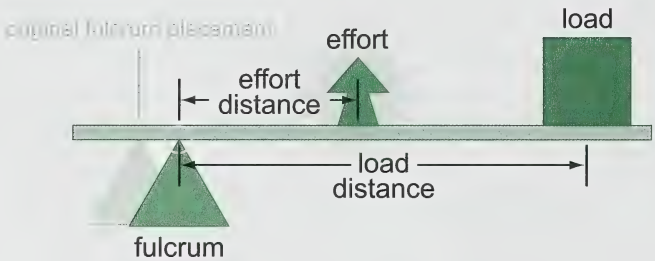


Third Class Lever

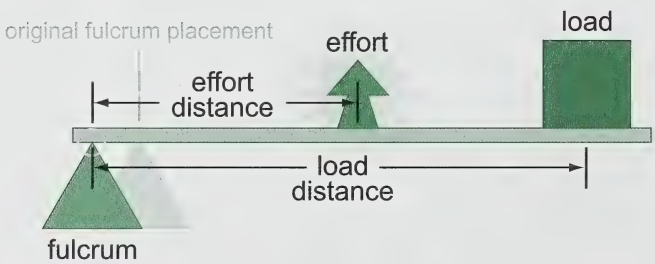
Here is a general diagram of a third class lever.



When the fulcrum moves toward the effort and the load, both load distance and effort distance decrease the same amount.



When the fulcrum moves away from the effort and the load, both load distance and effort distance increase the same amount.



Section 3: Lesson 3

1. A pulley is a grooved wheel.

2. A pulley is simple machine when it has a rope threaded around the pulley.

3. A pulley is in equilibrium when the effort applied on one end of the rope is equal to the load that is attached to the other end of the rope.

4. Data will vary. Sample data is given.

Part	Load (N)	Load Distance (N)	Work Done Without Pulley (J)	Using Pulley		
				Effort Required (N)	Effort Distance Required (m)	Work Done (J)
1	4	0.1	0.4	4.1	0.1	0.41
2	4	0.1	0.4	2.1	0.2	0.42
3	4	0.1	0.4	1.4	0.3	0.42

5. **Textbook questions 1, 2, and 3 of "Analyze," p. 141**

    1. The single-pulley setup required the most effort to lift the block of wood. A single pulley only changes the direction of the effort.

    2. The three-pulley setup required the least effort to lift the block of wood. When more pulleys are involved the effort is spread out over the number of pulleys that are involved.

    3. The cords were pulled longer and longer distances as the number of pulleys increased. The cord was pulled 10 cm in Part 1, 20 cm in Part 2, and 30 cm in Part 3.

6. The amount of work done is approximately the same for each set of pulleys.

7. Yes, this is reasonable because you are still lifting the same block.

8. Refer to the answers to question 5.

9. **Single Pulley**

$W = F \times d$
$= 4.1 \times 0.10$
$= 0.41$ J

Two-Pulley System

$W = F \times d$
$= 2.1 \times 0.20$
$= 0.42$ J

Three-Pulley System

$W = F \times d$
$= 1.4 \times 0.30$
$= 0.42$ J

The amount of work done is approximately the same for each system.

10. Yes, this is reasonable because you are lifting the same block of wood with each set of pulleys.

11. A fixed pulley is attached to a support, whereas a moveable pulley moves with the load.

12. A fixed-pulley sytem works much like a teeter-totter in that an effort equal to the load will balance the pulley system.

13. a. $\text{Force} = \frac{5400 \text{ N}}{3}$
$= 1800$ N

The force needed to lift the motor is 1800 N.

b. Distance $= 3 \times 1.5$ m
$= 4.5$ m

You need to pull the chain 4.5 m.

c. $\text{Distance} = \frac{6 \text{ m}}{3}$
$= 2$ m

The distance the motor will rise is 2 m.

14. A wheel and axle is any combination in which a larger wheel turns a smaller axle.

15. Examples of a wheel and axle include the following:

- screwdrivers
- door knobs
- wrench and nut
- winches

16. The effort distance on a wrench is approximately the length of the wrench (the distance from the centre of the nut to the centre position of your hand applying the force).

17. The load distance on a winch is the distance from the centre to the outside edge.

18. **Textbook question 1 of "What To Do," p. 144**

    1. Simple machines the Egyptians may have used could include the following:

        - ramps
        - levers
        - rollers
        - mallets
        - wedges

19. **Textbook question 2 of "What Did You Find Out?," p. 141**

    2. A simple machine that can move large blocks is a series of rollers that would be placed under the block.

20. **Textbook questions 1 to 5 of "Check Your Understanding," p. 144**

    1. A fixed pulley is attached to a support and does not move with the load. A moveable pulley moves with the load.

    2. A fixed pulley changes the direction of the effort. It is easier to pull down than to pull up because you can use your weight to pull down.

       A moveable pulley allows for multiple connections to the load. More cords support the load. This decreases the required effort, but it increases the required distance of motion.

    3. a. wheel and axle and lever (screw)

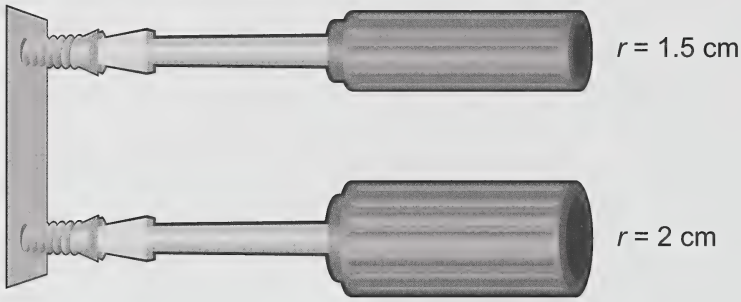
       b. pulley

       c. wheel and axle

       d. lever

       e. wheel and axle

4. Change to a fat-handled screwdriver. The effort distance is the radius, *r*, of the handle. The load distance is the radius of the shank of the screw. A fatter handle gives a greater effort distance.



5. Answers may vary. Here are some everyday items that use the wheel and axle as a force multiplier:

   - **doorknob:** Effort applied to a large outer wheel makes turning the small axle easier.
   - **bicycle pedals:** Effort applied to a pedal is transmitted to the chain by a much smaller axle.
   - **steering wheel:** Effort applied to a steering wheel turns the small steering rod.

   Force is multiplied because the wheel is much larger than the axle.

Section 3: Lesson 4

1. Three ways through which a machine will lose energy are

   - friction between moving parts
   - heat given off
   - poor combustion if the machine uses fuel

2. The energy would have been lost to friction when sliding the block up the incline.

3. You would use an incline because the force required to lift the block directly would be too large.

4. Friction is useful when it keeps things from slipping, especially when you don't want them to slip. For example, when riding a bicycle or driving a car, you do not want slippage to occur between the tires and the road.

5. Friction is not useful when it wears things out or causes inefficiency in machines.

6. Efficiency is a comparison of the work a machine does with the amount of energy it uses to do that work.

7. No machine is 100% efficient because some energy is always lost in a form that is not useable for the desired work.

8. Friction can be reduce by using a lubricant, such as oil, or by using an air cushion.

9. A lubricant will make a machine more efficient.

10. The most efficient is the battery. The least efficient is the incandescent light bulb.

11. The EnerGuide Number indicates how many kilowatt-hours of energy an appliance uses in one year.

12. **Textbook question "Reading Check," p. 146**

    The EnerGuide Number lets you compare the energy consumption of new appliances. When you buy a new appliance, you can choose one that will use the smallest amount of energy possible for the type of appliance you want to choose.

13. **Textbook questions 1 and 2 of "Analyze," p. 147**

    1. a. More energy was used in all pairs of months in 2000 than in 2001.

       b. Answers will vary. Reasons may include the following:

          - The cost of electricity went up, so this family tried to conserve.
          - They bought new, more efficient appliances.
          - They used the dryer less.
          - The weather was warmer.
          - There was less cloud and more sunshine, so the furnace ran less and lights weren't used as often.

c. Answers will vary. Reasons may include the following:

- During the winter, there is less sunlight. This means lights are on longer.
- The weather is colder. The furnace must be on more. The furnace fan uses a significant amount of electricity.
- People stay home more in the winter, so televisions, stereos, and lights are on more often.

2. Answers will vary. Sample ideas are as follows:

- Use the clothes dryer less by drying your clothes outside.
- Turn off unused lights and electrical appliances, like TVs, stereos, and radios.
- Save hot water by washing full loads of laundry (if water heater is electric).
- Save hot water by taking shorter showers instead of baths (if water heater is electric).
- Seal drafts around windows and doors.
- Increase the amount of insulation in attic.

14. a. Kilowatt-hours wasted $= \frac{(60 \times 365)}{1000}$

$= \frac{21\ 900}{1000}$

$= 21.9$

You will have wasted 21.9 kWh in one year.

b. Cost = 21.9 kWh x \$0.12 kWh
= \$2.63

The cost of the energy wasted is \$2.63.

c. This may not seem like a very large amount. However, suppose you have four light bulbs left on in unoccupied areas of the house for 3 h. The cost would be 12 times \$2.63, or \$31.54. If you consider this over hundreds of thousands of households across the country, it becomes a very significant energy cost.

15. Answers will vary. Sample answers are given.

    - The utility is trying to project an environmentally friendly face.
    - The utility is trying to save you money.
    - The utility can sell the power to someone else for more money.
    - The utility is trying to reduce demand because it has limited generation capacity.

16. Two benefits to using less energy are lower energy bills and reduced environmental problems.

17. Two environmental concerns regarding the use of fossil fuels are as follows:

    - Burning fossil fuels contributes to global climate change and air pollution.
    - Fossil fuels are non-renewable.

18. Two sources of energy that are not obtained from fossil fuels are wind energy and solar energy.

19. A Ballard fuel cell is a power supply for cars using hydrogen and oxygen to power the vehicle.

20. **Textbook questions 1 to 4 of "Check Your Understanding," p. 149**

    1. Factors that reduce the efficiency of machines include the following:

        - friction
        - waste heat
        - incomplete combustion

    2. Benefits of becoming more energy efficient include the following:

        - reduces environmental damage
        - saves money
        - saves non-renewable energy for future
        - saves resources that are needed for energy production

3. Ways in which a home may become more energy efficient include the following:

   - Improve insulation.
   - Install new windows.
   - Use energy-efficient lighting and appliances.
   - Reduce temperatures.
   - Reduce the use of air-conditioning.
   - Plant shade trees and wind breaks.

4. Disadvantages of becoming more energy efficient include the following:

   - A lifestyle change may be required.
   - Energy-efficient appliances and lighting may cost more (initially).
   - Public transportation may be inconvenient.
   - Walking and cycling may be slower and more difficult.

Section 3 Review

1.

E	K	K	F	O	T	P	E	Y	V	A	S	Z	R	Z
F	N	S	I	M	U	L	T	I	P	L	I	E	R	H
F	Y	A	E	L	C	B	S	X	R	E	M	M	G	F
I	Q	G	L	Q	O	Q	W	S	L	J	P	H	I	W
C	E	E	R	P	U	W	G	B	O	Y	L	X	V	A
I	Y	E	D	E	D	I	A	U	A	B	E	I	P	F
E	G	J	J	F	N	E	L	T	D	D	M	P	F	Q
N	R	J	S	F	V	E	N	I	T	B	A	V	U	A
C	E	T	U	O	I	M	L	I	B	–	C	C	L	L
Y	N	U	M	R	V	R	Z	A	L	R	H	C	C	C
T	E	E	E	T	B	L	M	X	M	C	I	O	R	W
H	A	V	T	Q	R	Q	E	L	T	R	N	U	U	O
N	E	W	T	O	N	–	M	E	T	R	E	I	M	R
L	O	X	N	H	H	R	I	E	H	M	Z	H	Y	K
P	O	J	C	A	H	L	H	Z	U	W	E	K	T	E

2. a. **Textbook question 1 of "Reviewing Key Terms," p. 150**

1. a. wheel and axle b. work c. force

d. pulley e. distance multiplier f. energy

g. force multiplier h. second class lever i. first class lever

j. efficiency k. inclined plane l. moveable pulley

m. simple machine n. third class lever

b. **Textbook questions 3 and 5 of "Understanding Key Ideas," p. 150**

3. A second class lever has the fulcrum at one end, the load in the middle, and the effort at the other end. Examples of a second class lever include a wheelbarrow, nutcracker, garlic press, and bottle opener.

5. Turning a large vehicle will be harder than turning a small vehicle. The mechanical advantage of a wheel and axle is related to the size of the wheel. The larger wheel gives a greater reduction in effort needed than a smaller wheel. This greater reduction is needed more with the large vehicle than with the small vehicle.

c. **Textbook question 7. a. of "Problem Solving/Applying," p. 151**

7. a. The force, *F*, is 5.0 N. The distance, *d*, is 0.2 m.

Work = Force x Distance
= 5.0 N x 0.2 m
= 1.0 N•m or 1.0 J

The dog did 1.0 J of work.

d. **Textbook question 10 of "Critical Thinking," p. 151**

10. A moveable pulley is attached to the object. The cord is attached at one end, then passes around the moveable pulley. The moveable pulley allows the weight of an object to be carried by two ropes. This halves the force that has to be applied. The downside is that the force has to be applied through twice the distance. (You have to pull out twice as much cord.)

Image Credits

Cover
main: PhotoDisc Collection/Getty Images
inset: PhotoDisc Collection/Getty Images
background: PhotoDisc Collection/Getty Images

Title Page
main: PhotoDisc Collection/Getty Images
inset: PhotoDisc Collection/Getty Images
background: PhotoDisc Collection/Getty Images

Welcome Page
PhotoDisc Collection/Getty Images

Contents (two-page spread)
top banner: PhotoDisc Collection/Getty Images
bottom banner: PhotoDisc Collection/Getty Images; Corel Corporation

Page
6 **banner:** PhotoDisc Collection/Getty Images
7 **banner:** PhotoDisc Collection/Getty Images
8 **both:**PhotoDisc Collection/Getty Images
banner: PhotoDisc Collection/Getty Images
9 **banner:** PhotoDisc Collection/Getty Images
10 **main:** NASA
banner: PhotoDisc Collection/Getty Images; EyeWire Collection/Getty Images
11 **left and bottom right:** PhotoDisc Collection/Getty Images
14 EyeWire Collection/Getty Images
15 **all:** PhotoDisc Collection/Getty Images
16 **top:** PhotoDisc Collection/Getty Images
bottom: © 2002–2003 www.clipart.com
17 PhotoDisc Collection/Getty Images
18 **frame:** PhotoDisc Collection/Getty Images
bottom: PhotoDisc Collection/Getty Images
19 **both:** PhotoDisc Collection/Getty Images
21 **both:** © 2002–2003 www.clipart.com
22 **left:** EyeWire Collection/Getty Images
right: PhotoDisc Collection/Getty Images
23 EyeWire Collection/Getty Images
25 PhotoDisc Collection/Getty Images
27 PhotoDisc Collection/Getty Images
28 PhotoDisc Collection/Getty Images
31 Corel Corporation
34 PhotoDisc Collection/Getty Images
35 PhotoDisc Collection/Getty Images
36 **both:** PhotoDisc Collection/Getty Images
39 PhotoDisc Collection/Getty Images
41 **main:** PhotoDisc Collection/Getty Images
banner: Corel Corporation
42 Corel Corporation
45 PhotoDisc Collection/Getty Images
47 PhotoDisc Collection/Getty Images
49 PhotoDisc Collection/Getty Images
58 © 2002–2003 www.clipart.com
59 **left and top right:** PhotoDisc Collection/Getty Images
bottom right: Corel Corporation
60 Corel Corporation
61 Digital Vision/Getty Images
63 **both:** PhotoDisc Collection/Getty Images
64 PhotoDisc Collection/Getty Images
65 **main:** Digital Vision/Getty Images
banner: EyeWire Collection/Getty Images; Digital Vision/Getty Images; PhotoDisc Collection/Getty Images
66 **both:** PhotoDisc Collection/Getty Images
69 **top:** PhotoDisc Collection/Getty Images
70 Brendan Byrne/Digital Vision/Getty Images
76 Digital Vision/Getty Images
77 **all:** PhotoDisc Collection/Getty Images
81 **all:** PhotoDisc Collection/Getty Images
82 PhotoDisc Collection/Getty Images
83 PhotoDisc Collection/Getty Images
84 PhotoDisc Collection/Getty Images
90 PhotoDisc Collection/Getty Images
91 **top left:** EyeWire Collection/Getty Images
top right: PhotoDisc Collection/Getty Images
92 EyeWire Collection/Getty Images
93 PhotoDisc Collection/Getty Images
94 **top:** PhotoDisc Collection/Getty Images
95 Corel Corporation
96 PhotoDisc Collection/Getty Images
97 PhotoDisc Collection/Getty Images
101 **main:** PhotoDisc Collection/Getty Images
inset: PhotoDisc Collection/Getty Images
background: PhotoDisc Collection/Getty Images

© 2003